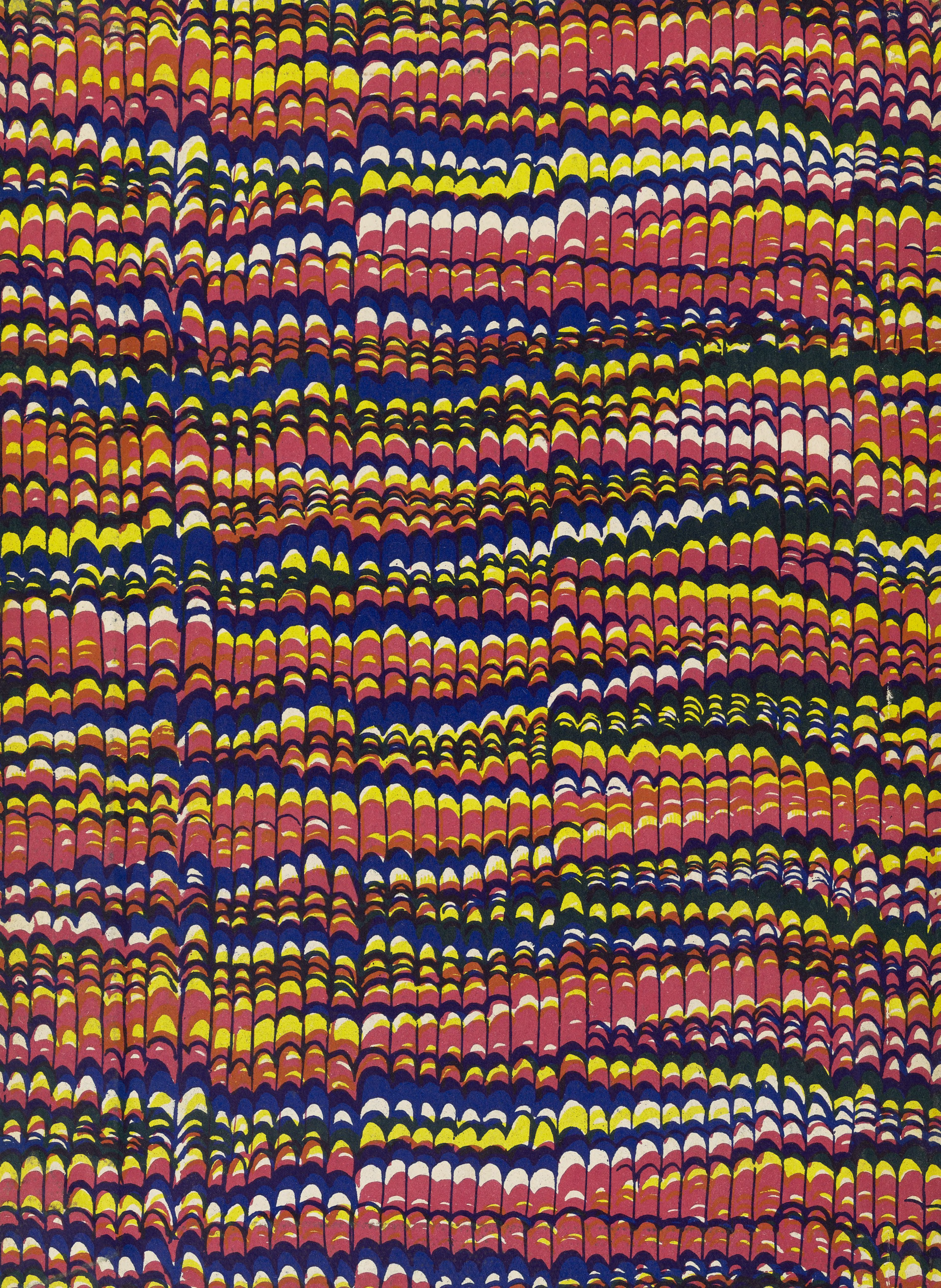

VOL. XXXIII, No. 1

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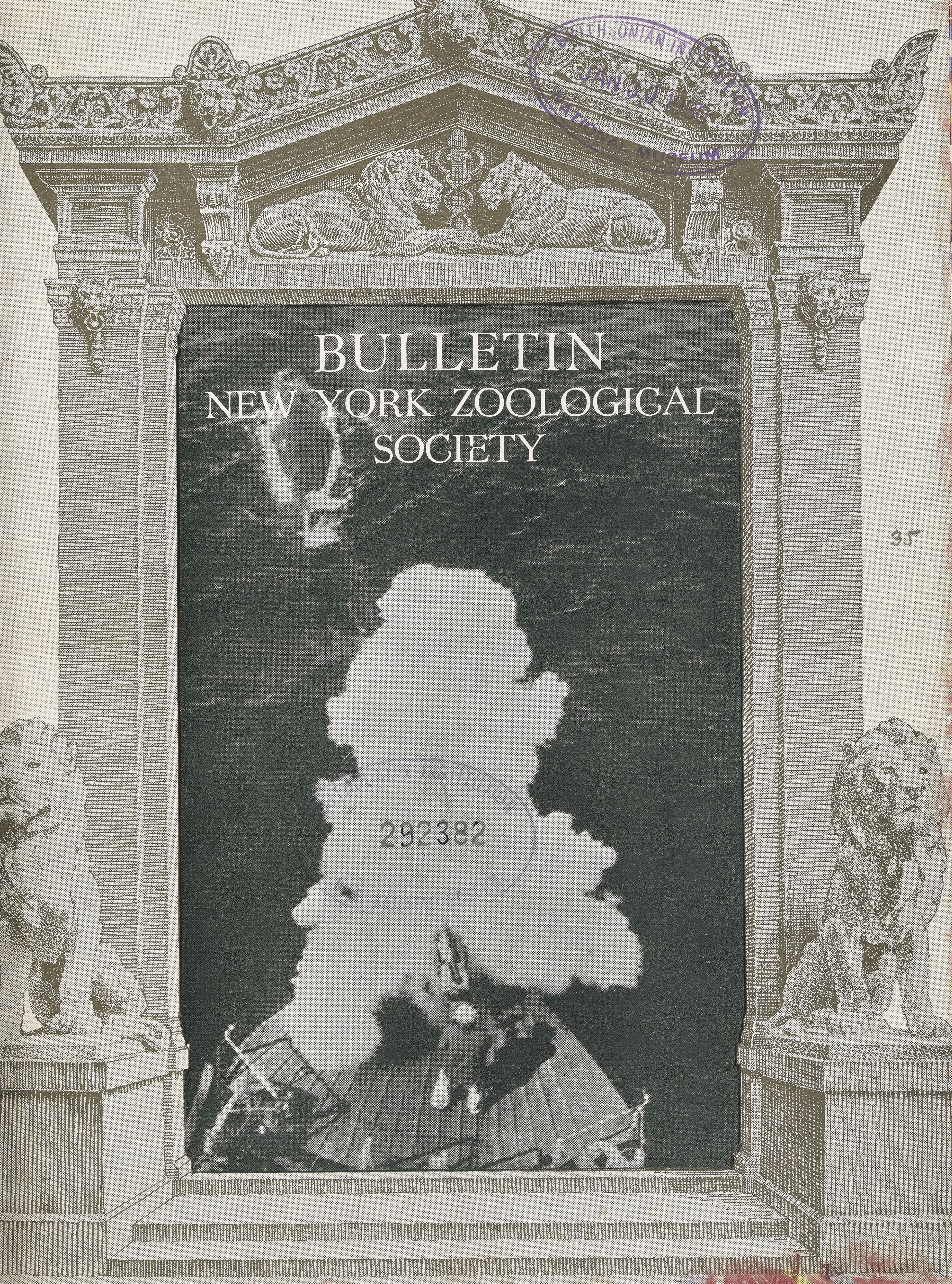

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NEW YORK ZOOLOGICAL SOCIETY

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Killer *(Orca gladiator)*. The most ancient enemy of the whale.
Painting by Charles R. Patterson.

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NEW YORK ZOOLOGICAL SOCIETY

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Twentieth Century Whaling

Charles Haskins Townsend
Director, New York Aquarium

Illustrations from photographs made by the author unless otherwise noted

Introduction

The Old and the New

THE whaling industry of the nineteenth century reached its zenith in 1846 when there were 735 vessels in the American fleet alone. It did not die at once when petroleum came into general use as an illuminant after the middle of the century. There was still a market for whale oil and whalebone, but profits from the business diminished steadily. Few new whaleships were built, and before the close of the century, the taking of whales by ships using open boats for harpooning came practically to an end. Many vessels had been lost during the Civil War. Some were destroyed by Confederate cruisers. The Government purchased forty-five which were filled with stone and sunk in attempts to close the channels to southern harbors. Steel had taken the place of whalebone for many light articles and mineral oils were coming into use for various purposes.

My introduction to old time whaling began in June, 1885, when as naturalist on the Arctic voyage of the U.S.S. "Corwin" I visited whaleships at Bering Straits awaiting a movement of the ice that would permit their entry into the Arctic Ocean. These were the steam whalers *Balaena* and *Orca* and the barks *Helen Mar, Jacob A. Howland* and *Fleetwing.* Later, above the Straits, the "Corwin" found the barks *Wanderer, Dawn, Mary and Susan, Stamboul, Mabel, Arnolda, George and Susan, Ohio, Francis Palmer,* and *Reindeer.*

A few of these vessels were already more than forty years old, the *George and Susan* being seventy-five. The steam whalers were comparatively new, being full-rigged sailing vessels with auxiliary power. The bark *Wanderer,* built in 1878, was one of the few whaleships that lasted into the next century, remaining afloat until 1924—the last of the American sailing whalers. There were in 1885 thirty-two of these old time whaleships in the Arctic. Some of them ended their careers that season. The *George and Susan* and the *Mabel* dragged their anchors and went ashore during a gale. The *Gazelle, Rainbow,* and *Stamboul* were crushed in the ice, the last losing twenty-two men. Some of the ships that were between the ice and the Alaskan lee shore were towed to positions of safety by the "Corwin." Some of the survivors from the wrecked vessels were distributed among other vessels of the fleet. The remaining fifty-four castaways, more or less ragged and frost-bitten, had to be packed

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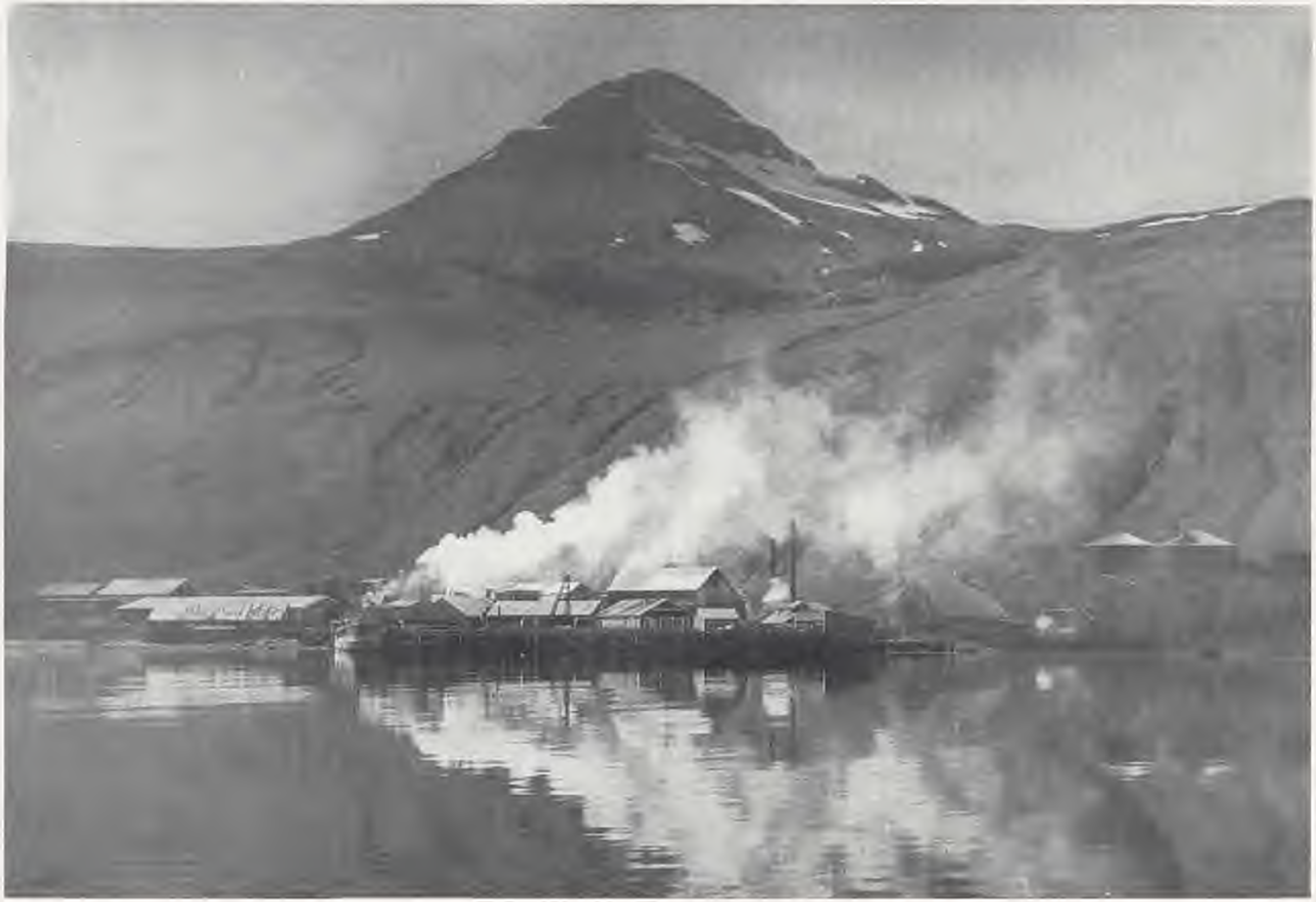
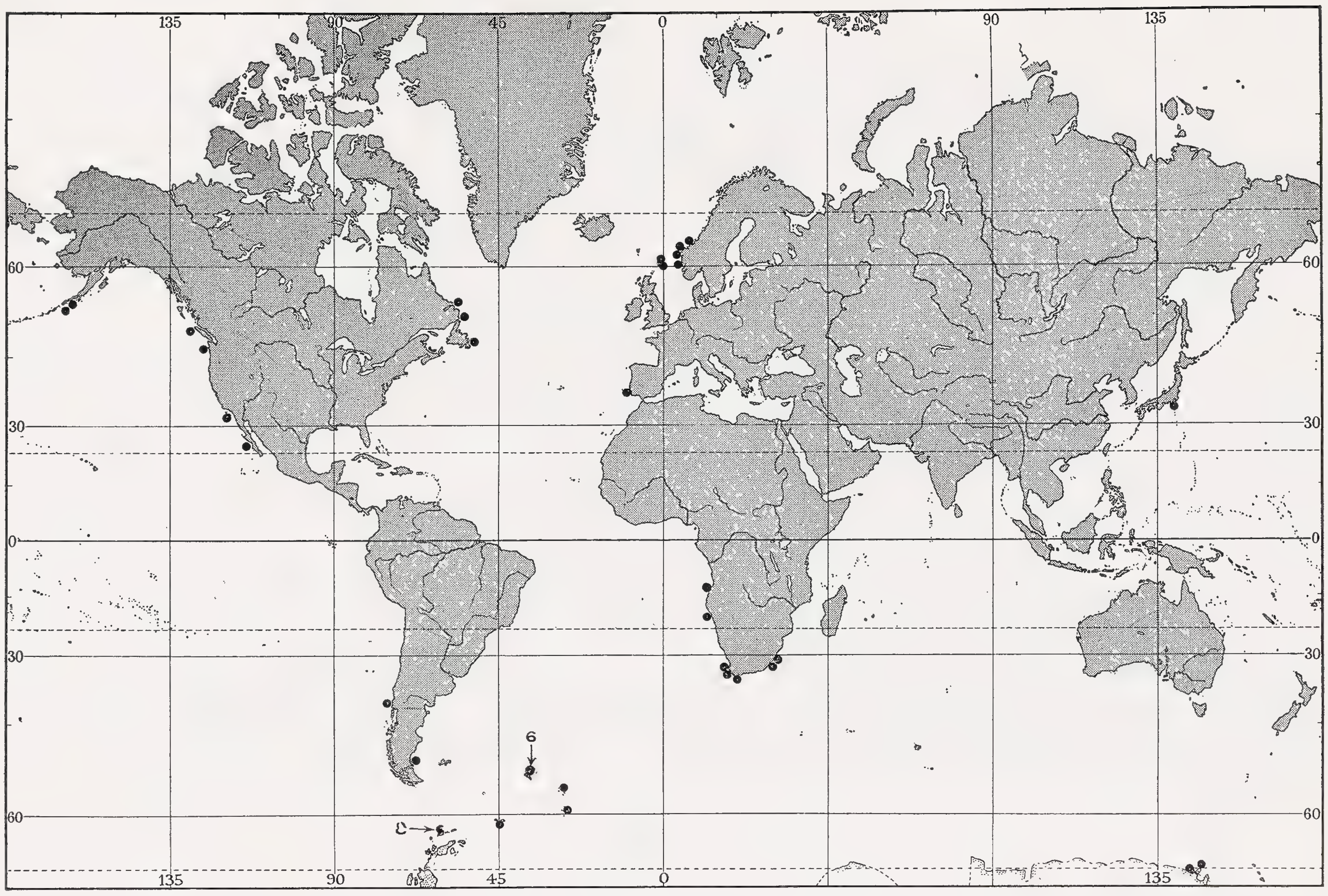
*Rept. Arctic Cruise, U.S.S. "Corwin," 1885. Hs. of Representatives. 49th Cong. 1st Sess. Ex. Doc. No. 153.



At the entrance to Bering Sea. A shore whaling station at Akutan Island, Alaska.



Map showing the stations of the whaling companies operating in 1928-1929. (After the Register of the Whaling Fleet, Whalers' Mutual Insurance Association, Sandefjord, 1928.) Courtesy of the *Geographical Review.* Published by the American Geographical Society of New York.

into the "Corwin" for transportation home, to the enormous discomfort of all of us. Disasters in Arctic whaling had happened before. In 1871 thirty-four whaleships above Bering Straits were either crushed or driven ashore by the ice. This was the greatest calamity that befell the old time fleet. In December, 1885 I visited certain localities on the coast of California where the taking of whales by open boats operating from whaling stations located on shore was still practiced.* The few stations remaining in operation were located at Monterey, San Simeon, San Luis Obispo, Point Conception and San Diego. The fishery was based on the Pacific Gray Whale, other species being rarely taken, and the industry was declining. It is not our purpose to discuss here, whaling methods of the past. They have been well described in many books. What has been written above is merely a personal side light on the subject.

The whaling industry of today is carried on by methods that are vastly more efficient. It is based chiefly on species of whales that could not be captured by such equipment as was formerly employed. The change in methods was gradual. A few sailing vessels, in ever diminishing numbers, remained in service after the close of the nineteenth century, while large steam-powered hunting boats, working from shore stations, had already been in use for several years.

The hand-thrown harpoon had been replaced by the Svend Foyn cannon, firing a heavy projectile with line and explosive bomb attached. During the period of transition from the old methods to those of the new, the taking of whales was aided greatly by the use of a bomb gun fired from the shoulder after the harpoon had been thrown. While the catch of the old-time whaler was limited to the slower moving whales such as the sperm and the right whale, the improved equipment of today permits the capture of the great blue whale, the finback, the humpback, the sei whale and others too speedy for the open whaleboat. They are

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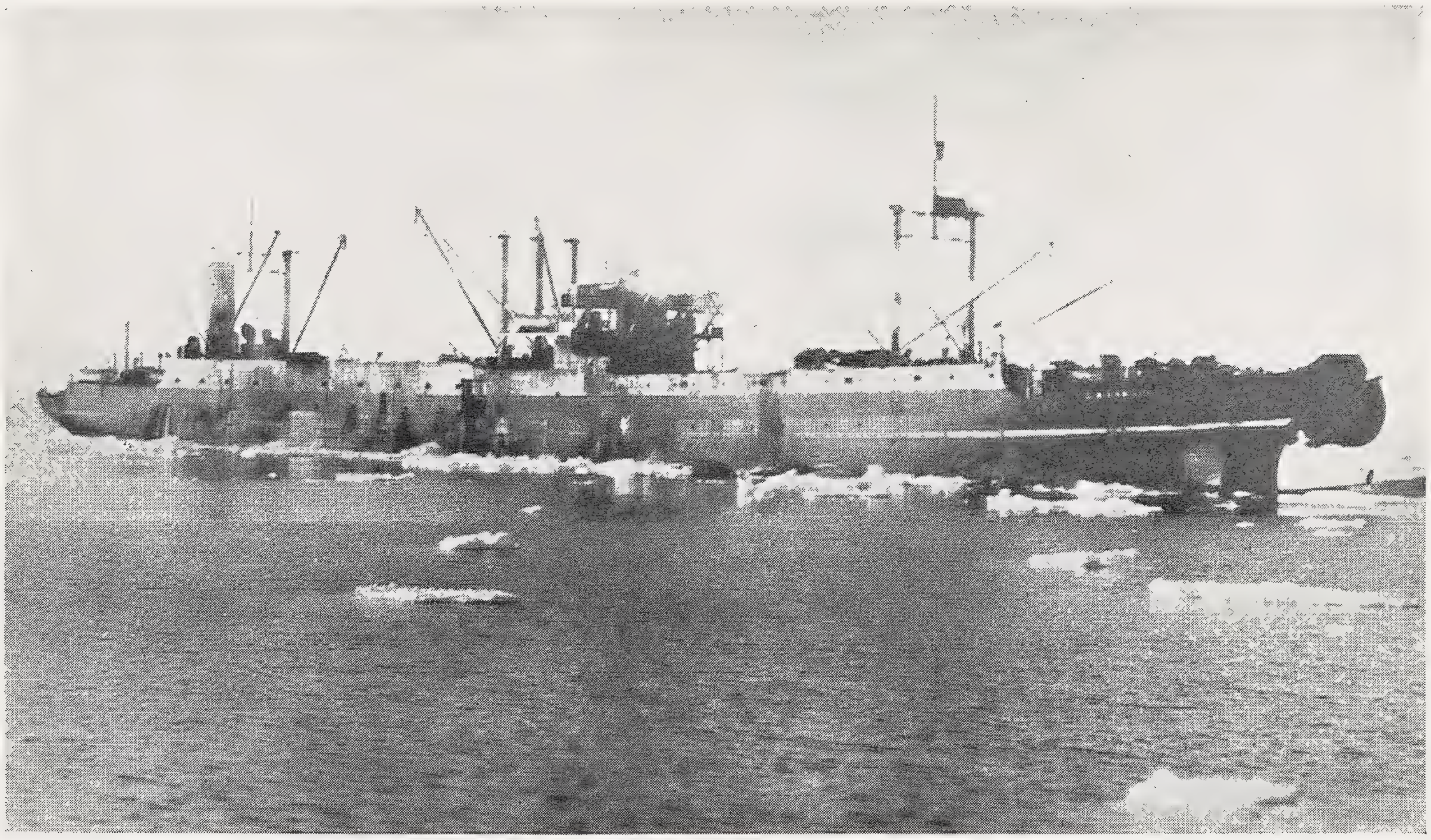
*Calif. Gray Whale Fishery. C. H. Townsend. Bull. U.S. Fish Cruise. 1886.



The factory ship *C. A. Larsen* at work in the Ross Sea.
Photo from Bryn, Sandefjord.

moreover, species that sink after being killed, and have to be raised by steam power and inflated for towing to the shore base.

Modern Methods of Whaling.—The preparation of oil and other whale products at well-equipped stations where whales are dragged bodily onto flensing platforms has long been in practice in the many regions north and south where whales are taken. More recently this method has been giving way to the use of floating factories, while shore stations are being abandoned as local supplies of whales become exhausted. Factory vessels are readily sent to favorable whaling regions, accompanied by their steam hunting boats. The oil obtained is stored on board until it can be transferred to other vessels or landed at favorable shipping points. While all products derived from whales, such as oil, fertilizer, bone meal and canned meat, are utilized at stations located on shore, the floating factory except in the case of a very large one, is as yet able to reduce the oil only, other products being rejected for lack of space required for their preparation on board.

The floating factories as originally constructed, cut up the whales brought alongside by hunting boats and hoisted all parts on board. The larger vessels now being built are provided with slips usually located at the stern above the propellers, through which all whales are *pulled on board* before being cut up.

Some of the factory steamers already in use exceed 12,000 tons in size. A new vessel of more than 22,000 tons recently began operations in the Ross Sea section of the Antarctic. This vessel, the *Kosmos,* is accompanied by seven steam hunting boats and an airplane. The *Kosmos* is reported to have two working decks, one for oil production and one for the preparation of fertilizer. There is also equipment for the canning of whale meat.

Floating factories are equipped for radio communication with their hunting boats. The larger ones can dispose of six or eight large blue whales a day, and more than twice as many of the smaller kinds. The larger blue whales may yield as much as seventy-five barrels of oil apiece, humpbacks and fin whales about half as much. The yield of oil depends upon the condition of the whale captured.

The whaling industry of today is conducted with enormously expensive equipment, but yields accordingly greater profits. The value of whale oil is, moreover, greater than ever before, being at present worth about $26 a barrel. The bulk of it is used in soap-making industries which are indeed competing in the purchase of it in large quantities. The supply of oil is frequently negotiated for in advance of the season's catch. Whaling as now carried on is largely a Norwegian industry. The greater part of the catch is made in Antarctic waters, amounting to about 70 per cent of the catch in all parts of the world.

Recent Whaling Activities.—In an article entitled Modern Norwegian Whaling in the Antarctic* Mr. Gunnar Isachsen states that more than 20,000 whales have been killed annually in the Antarctic during recent years. In addition to the shore stations located at South Georgia and other Antarctic islands, there were during the season of 1928-1929, eight floating factories. The catches made by the *Sir James Ross* and the *C. A. Larsen,* both of which arrived at New York in April, 1929, totaled 1,306 whales which yielded 126,000 barrels of oil valued at more than $3,000,000. The oil cargoes of both vessels were sold to the Proctor and Gamble soap factories of Staten Island and Cincinnati. The *Larsen* is a steamer of 13,426 tons, and carries a crew of 208 men. She has seven hunting boats, one of which killed 195 whales during the two months' season. Both the *Larsen* and the *Ross* have returned to the Ross Sea.

Dispatches from Norway, dated August 24, announced the most important preparations for Antarctic whaling on record. The fleet about to sail consisted of 190 steam hunting boats, thirty-seven factory steamers and seven transport steamers. Five of the last are to operate with twenty-seven of the factory ships in the Ross Sea, and twenty-five of the hunting boats go to the five shore whaling stations at South Georgia. According to Mr. Isachsen the Norwegians operated in the Antarctic last season, 1928-1929, with twenty-four floating factories, eighty-five hunting boats and three shore stations.

A Factory Ship.—In October, 1929, I had the opportunity of observing whaling opera-

(*Continued on page* 13)

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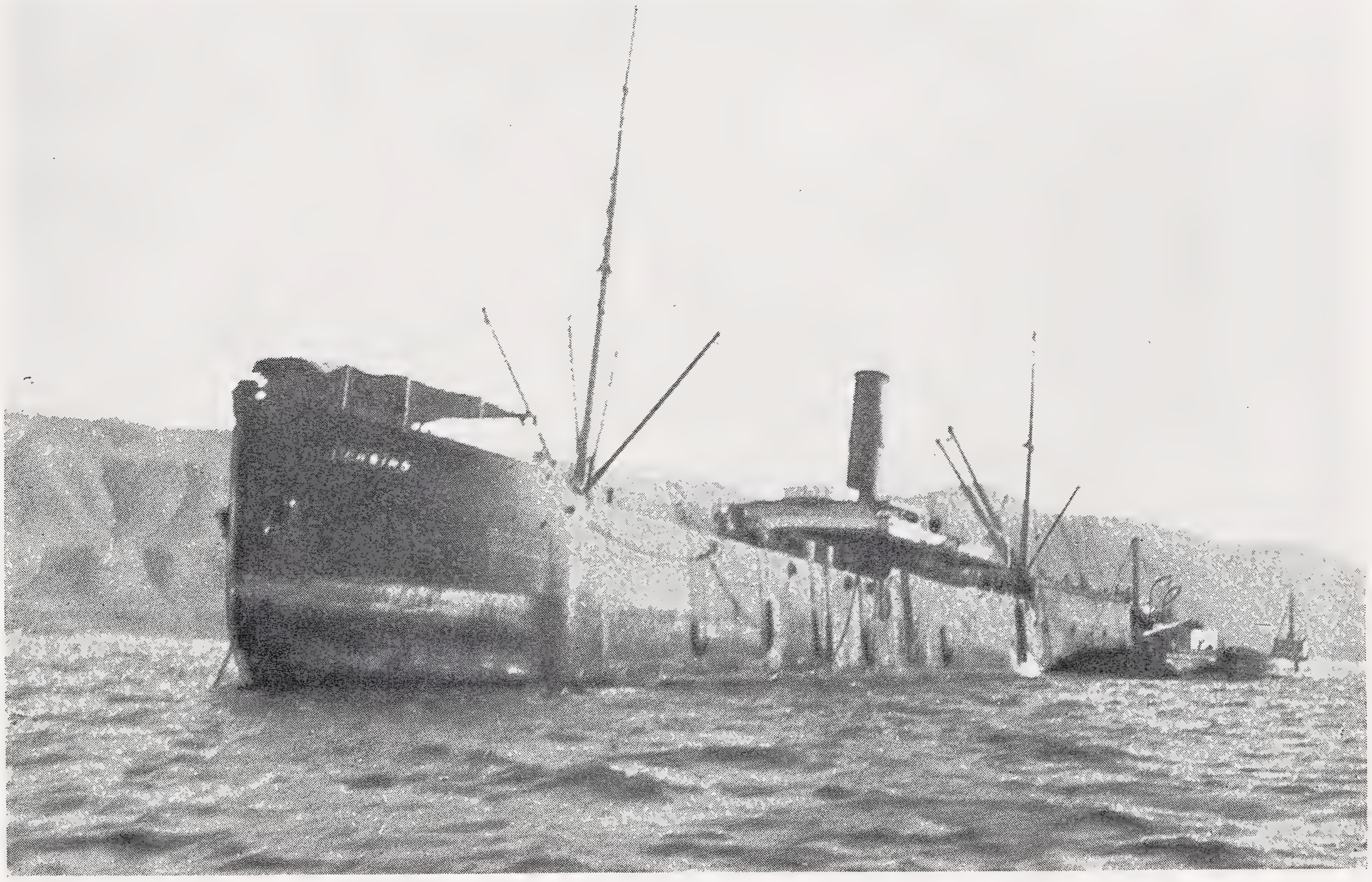
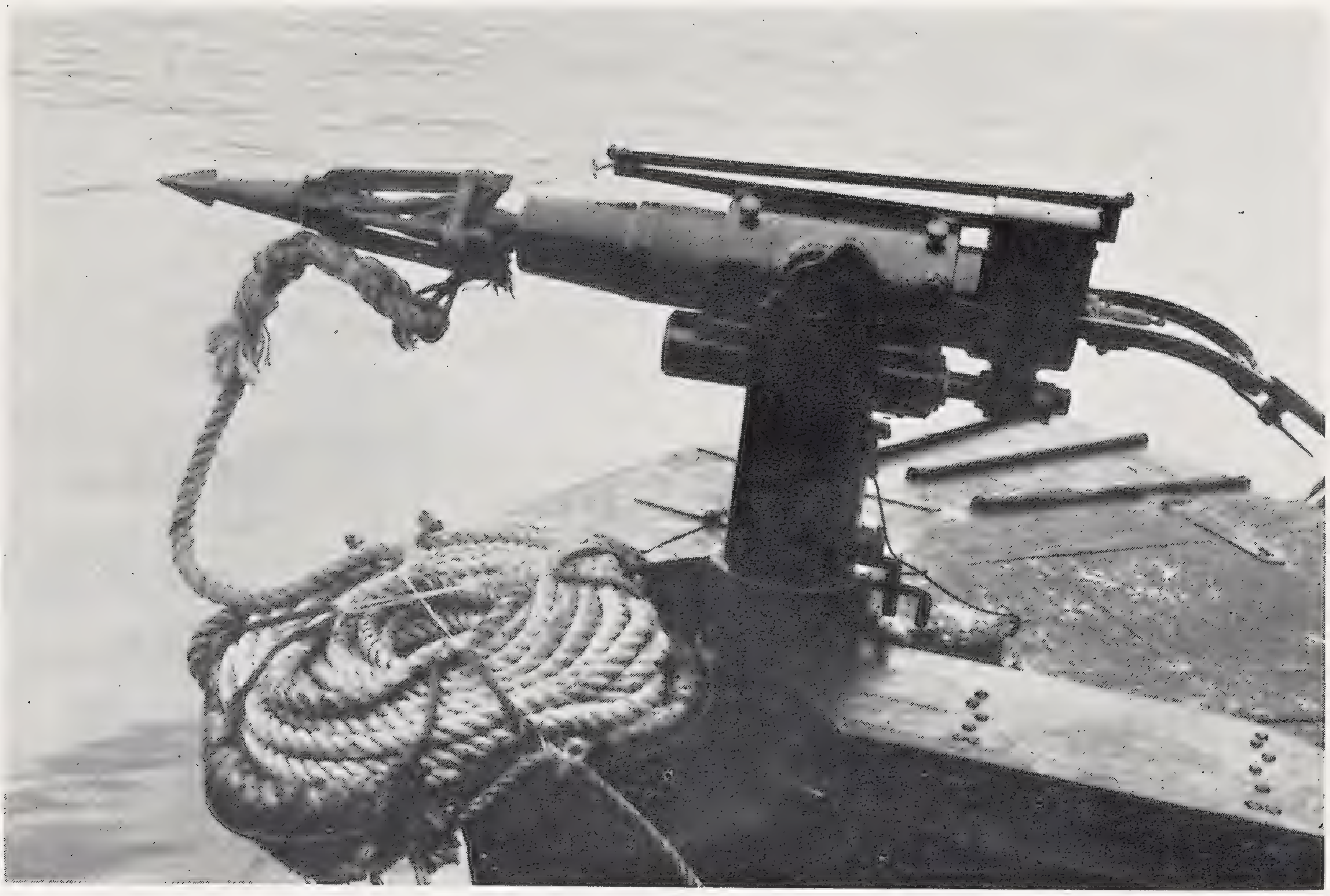
* Geog. Rev. July, 1929.

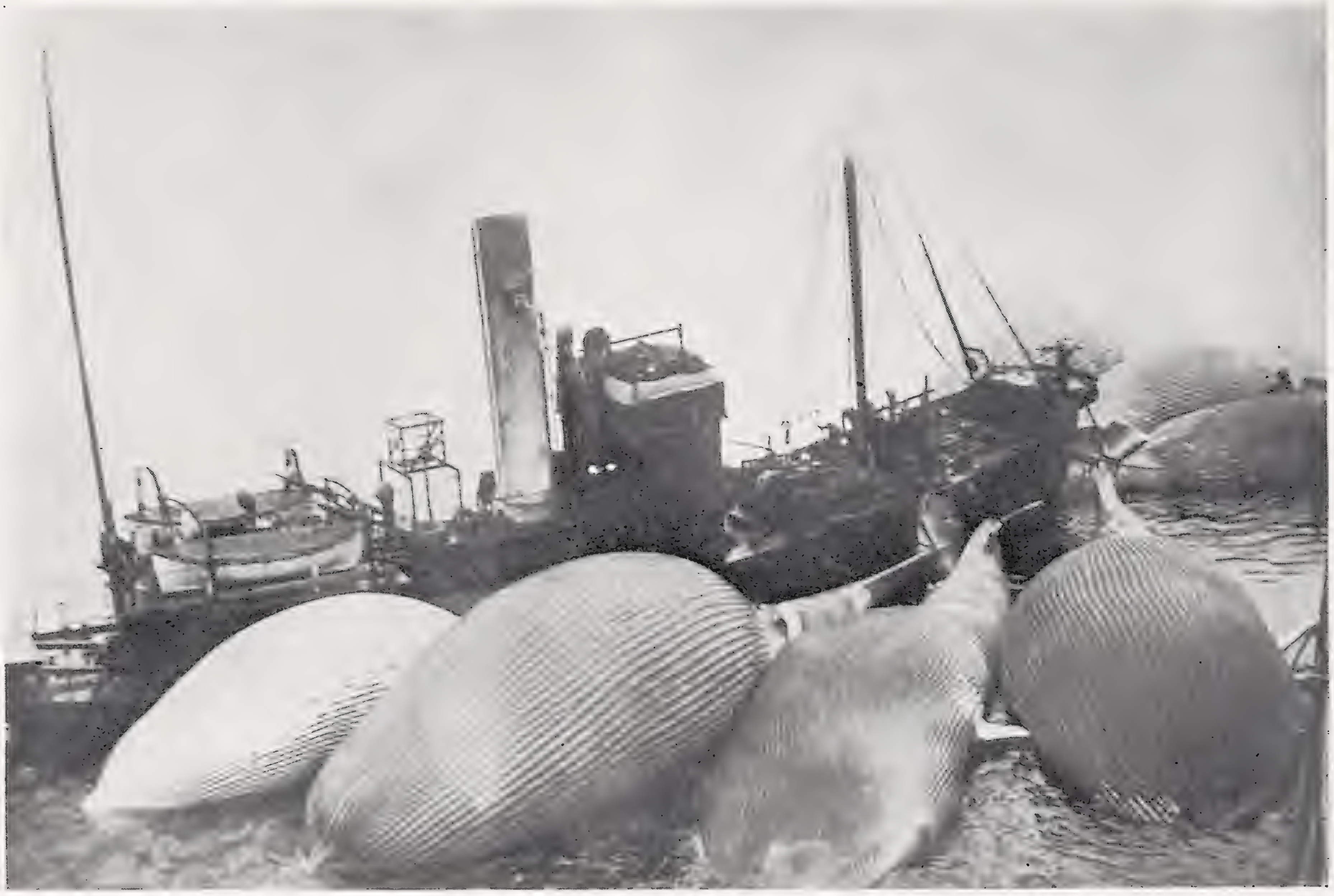


The factory ship *Lansing,* California Sea Products Company.

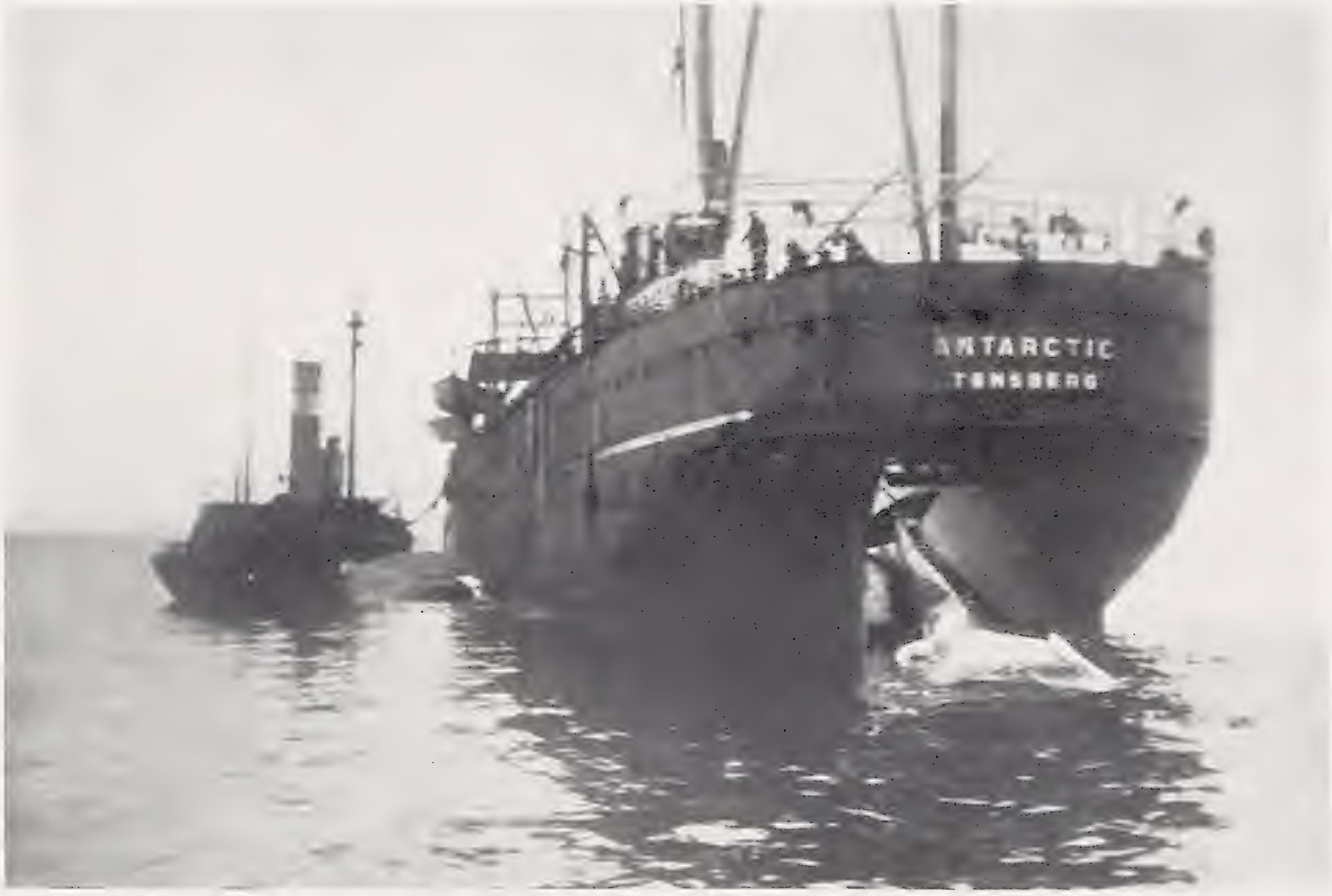


The Svend Foyn Gun, used by all twentieth century whalers, carries a line and an explosive bomb.

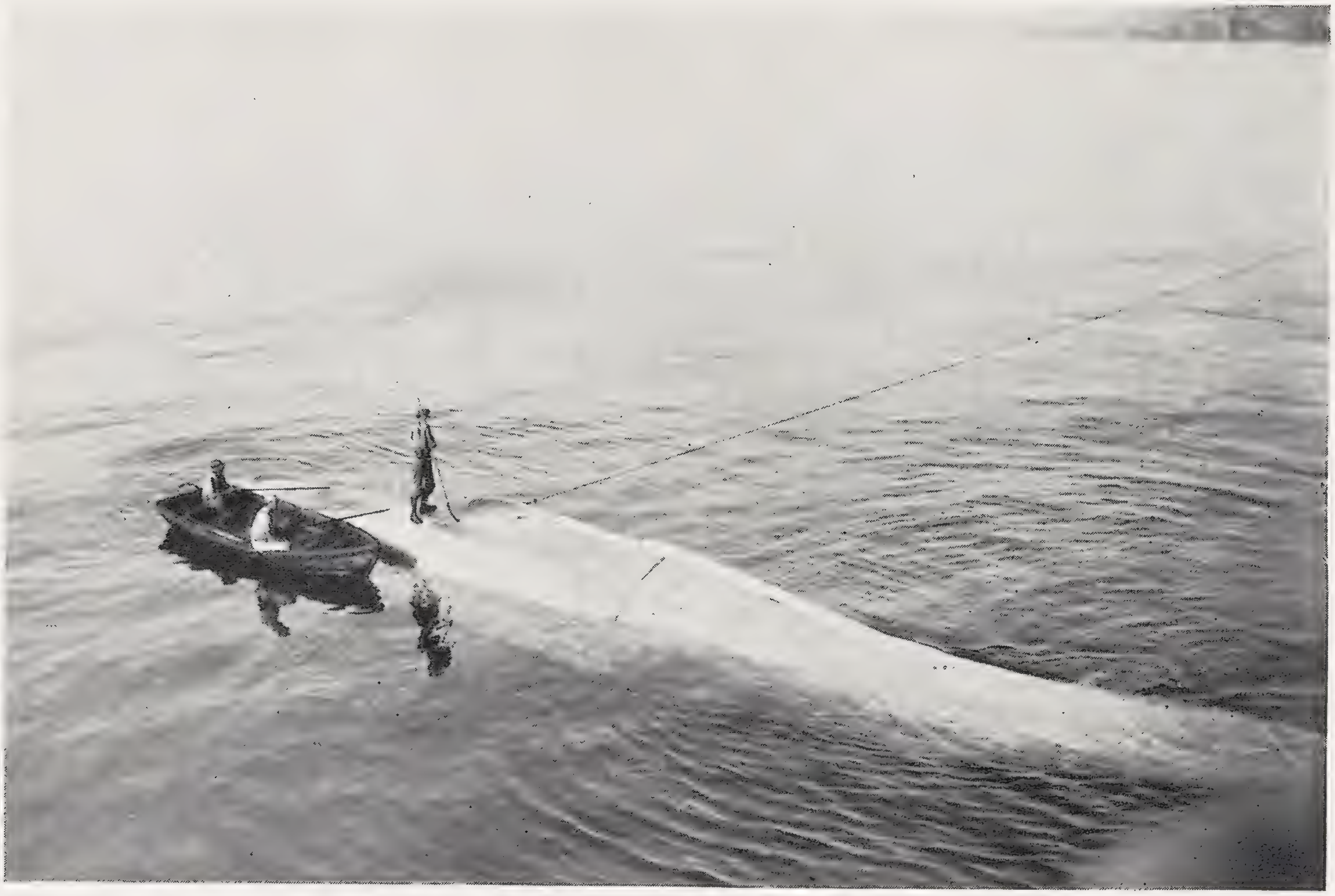
Hunting boat with her catch. Photo by Capt. M. Swanson.



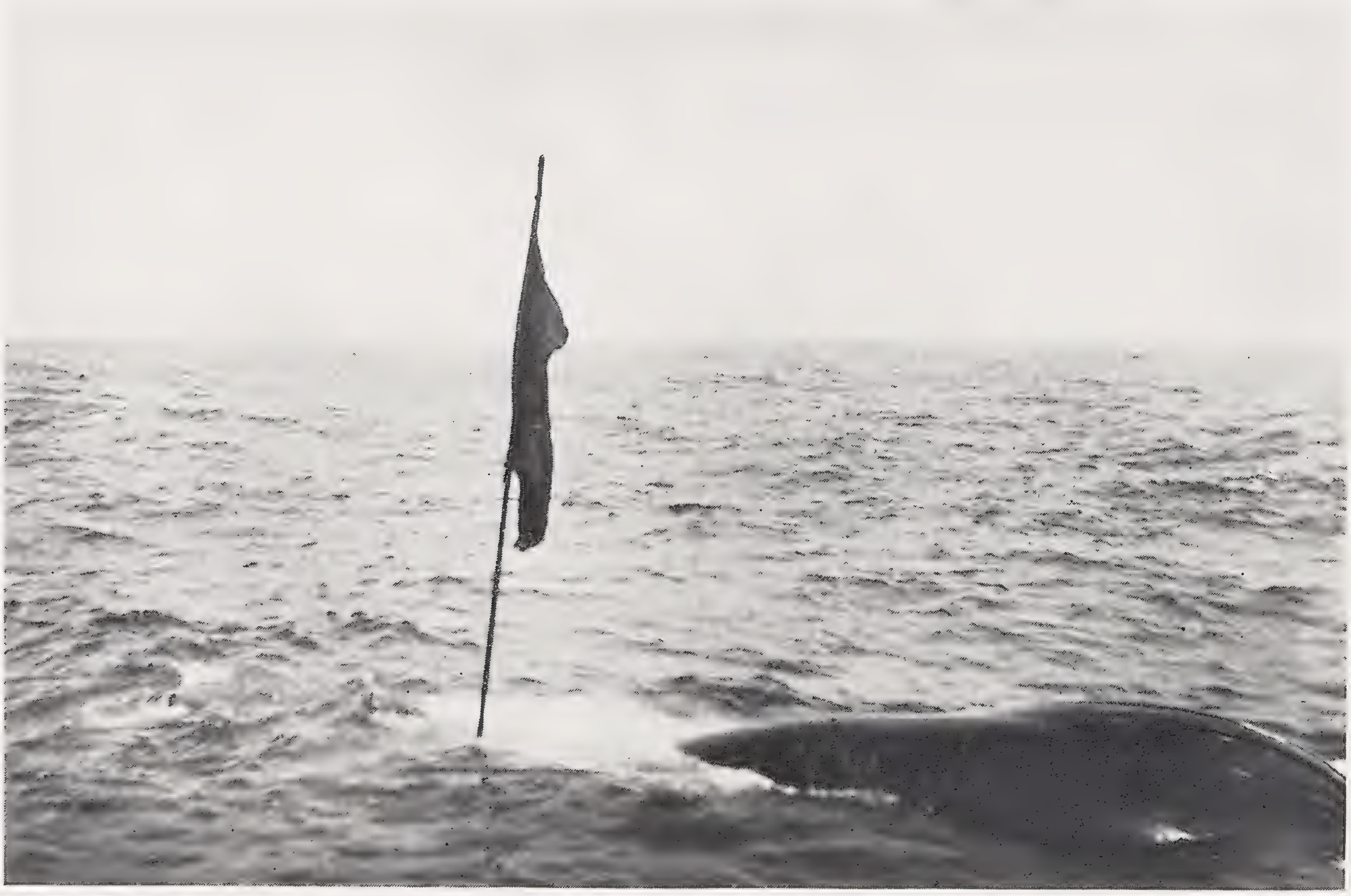
Hunting boat and seven whales. Whales are inflated by steam-driven air pump to prevent their sinking.
Photo from Bryn, Sandefjord.



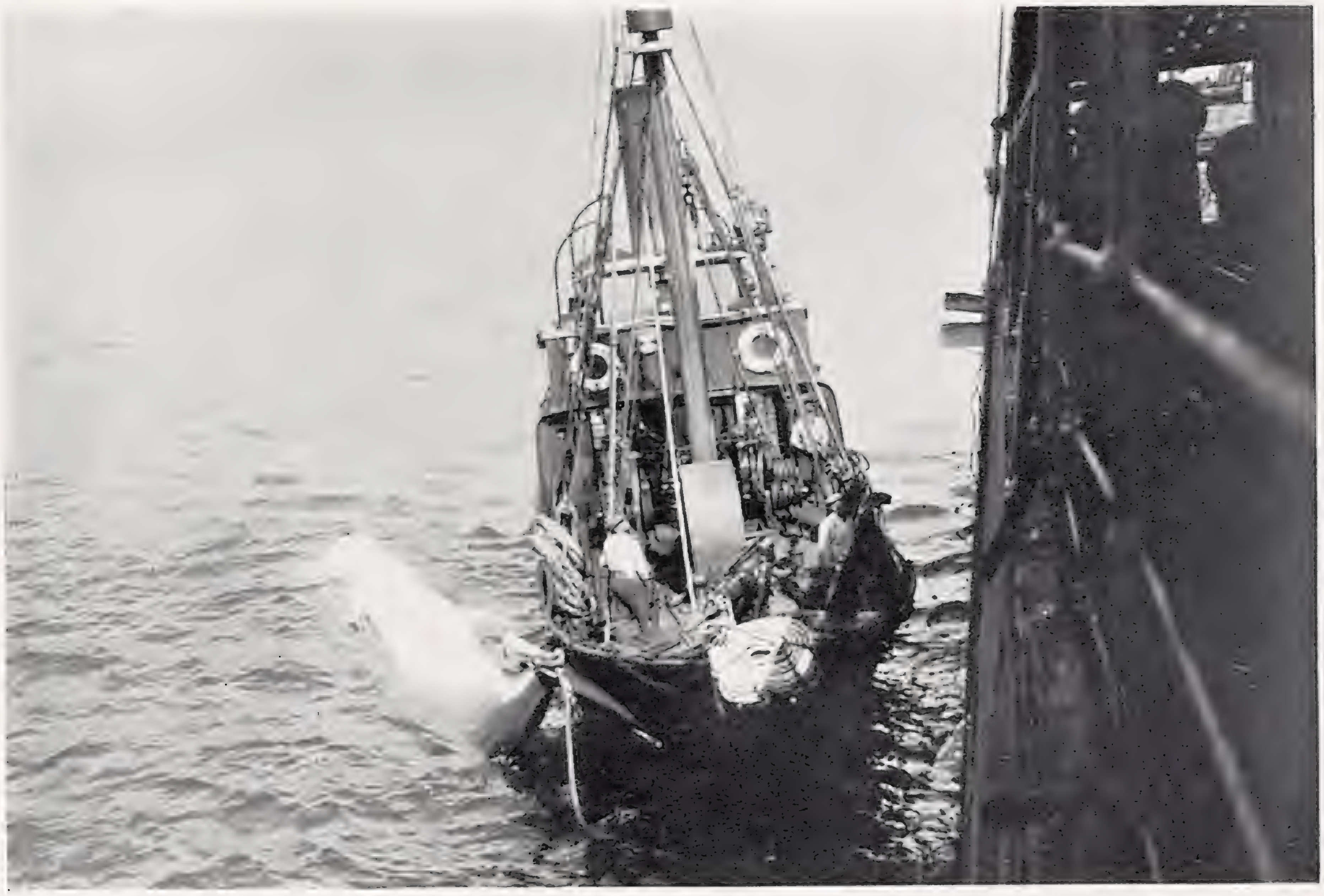
A factory ship and one of her hunting boats dragging a whale up the "slip."
Photo from Bryn, Sandefjord.



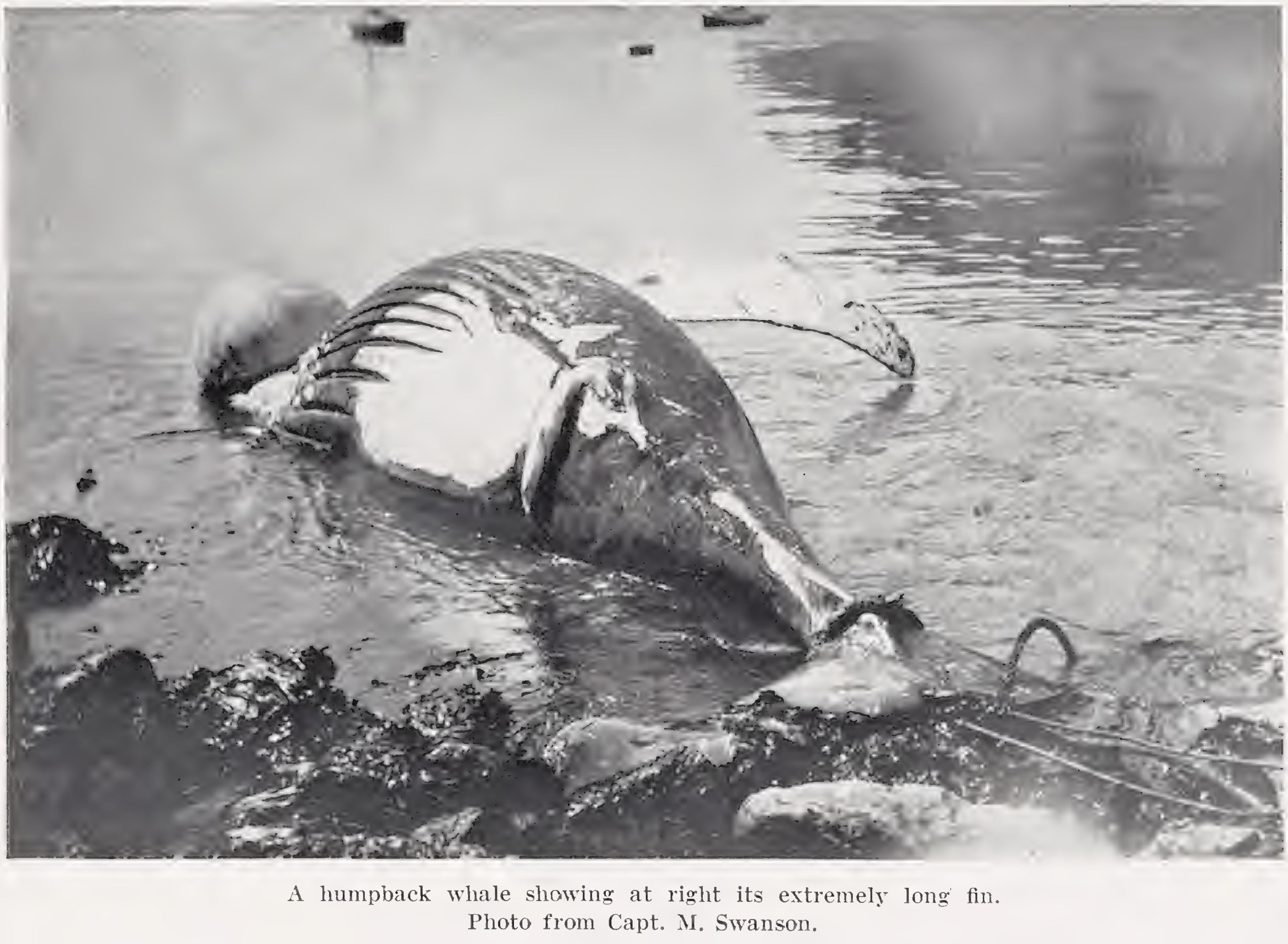
A blue whale eighty feet long. Photo by Capt. M. Swanson.



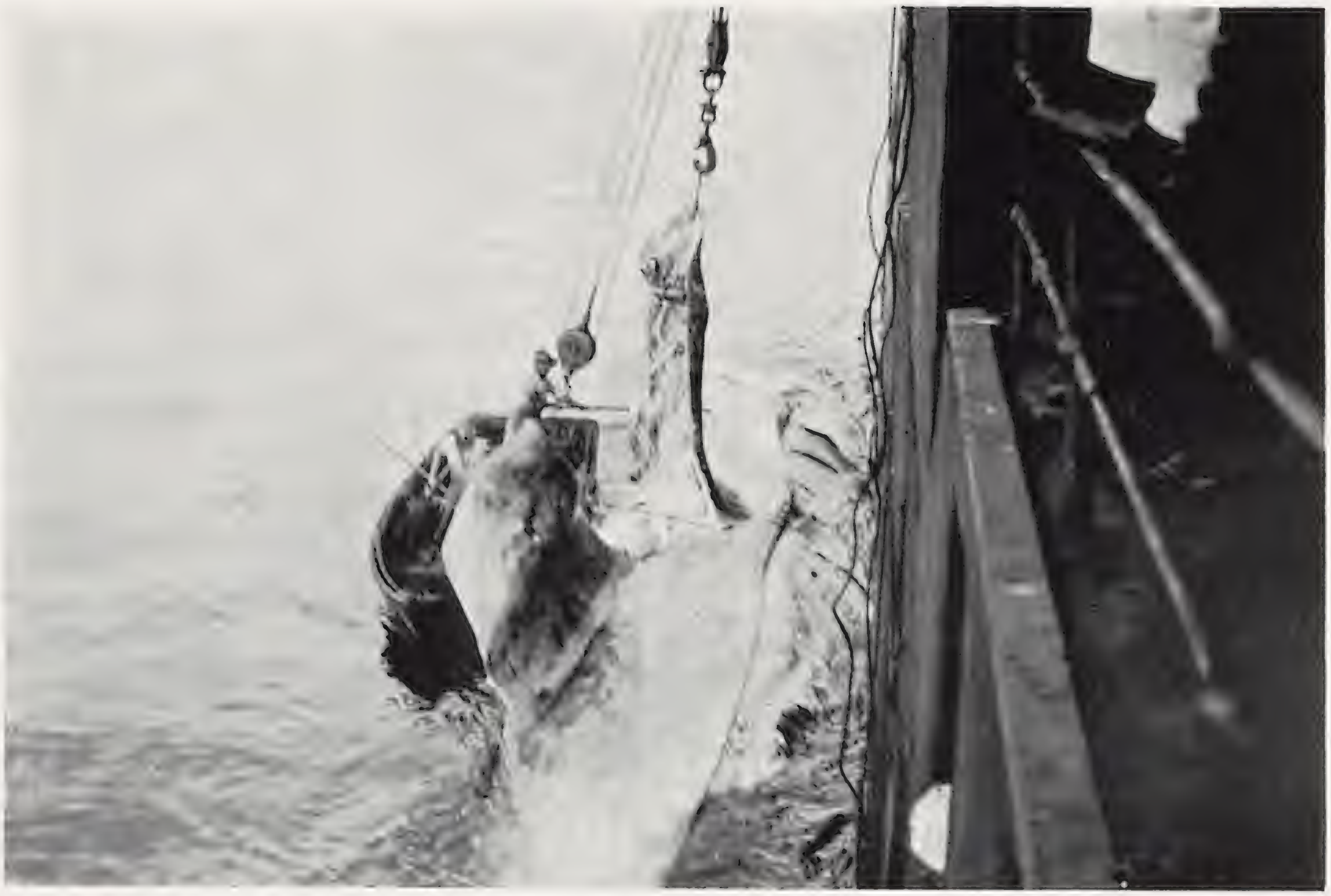
A whale "flagged" at sea while the boat continues hunting.



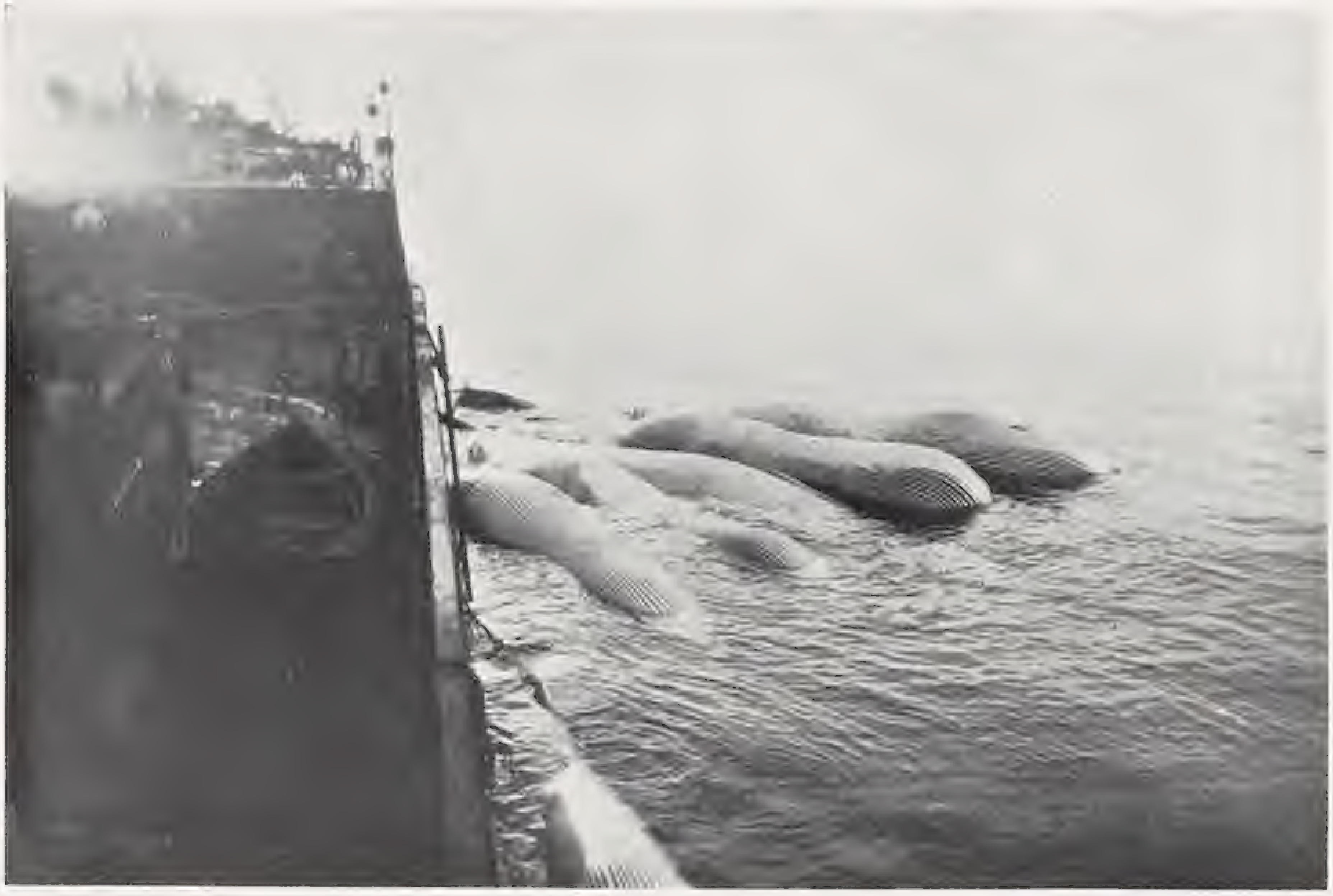
One of the hunting boats bringing in a small whale.



A humpback whale showing at right its extremely long fin.
Photo from Capt. M. Swanson.



Strips of blubber are cut loose by men in the boat, and hoisted to the flensing deck.



Five inflated whales alongside the factory ship.
Photo by Capt. M. Swanson.

tions as conducted at San Clemente Island, California. The floating factory *Lansing,* 7,000 tons, was anchored in Pyramid Cove at the south end of the island. To this point her four hunting boats *Hercules, Port Saunders, Hawk* and *Traveller* brought several whales during my stay. The average length of these boats is 100 feet. The species then being taken were blue whale, finback and humpback. The whales arriving in the evening were secured alongside the factory ship until morning, the hunting boats anchoring nearby until daylight. Occasionally a hunting boat was absent two days or longer on her cruise, but usually the whale brought in had been taken by a boat that had sailed in the morning. Hunting boats occasionally, on account of rough weather or failure to find whales returned without making catches.

The *Lansing* not having a slip through which whales could be dragged on board entire, cut up the catch alongside. The blubber was removed first, being cut free in large pieces by men in a small boat beside the whale. The head came next, then a long section of the tail, followed by the body in as large pieces as could be handled by the steam winches. All parts of the whale were thus hoisted to the flensing deck except the great mass of intestines which was towed seaward by a launch and set adrift to be disposed of by sharks. Sometimes sharks come in at night and tear whales alongside the factory ship. They also at times attack whales left afloat at sea temporarily by the hunting boats. Whales thus left are marked by flags while the boats continue hunting.

As the heavy masses of blubber, flesh and bone are hoisted, they are pulled to suitable positions on the flensing deck by winches, and are promptly attacked by the deck gang of sixteen or eighteen men. All parts are cut in pieces a foot or more square, and dropped into the open tops of eighteen large steel digesters located directly under the flensing deck. As these are filled, the lids are bolted down and steam turned on. In ten or twelve hours the oil has flowed off to storage tanks, and the residue of scrap and bones thrown overboard. Skull and jawbones, being stripped of fat and flesh, are dragged under large steam-driven saws, cut into pieces suitable for the digesters and are steam-boiled like the soft parts. The great masses of "whalebone" or baleen are detached from the upper jaws and thrown overboard. There is but little demand for "whalebone" at present, but at shore stations where it can be stored it is usually saved. At Japanese stations it is used for the manufacture of various fancy articles. Elsewhere it is used chiefly for making brushes.

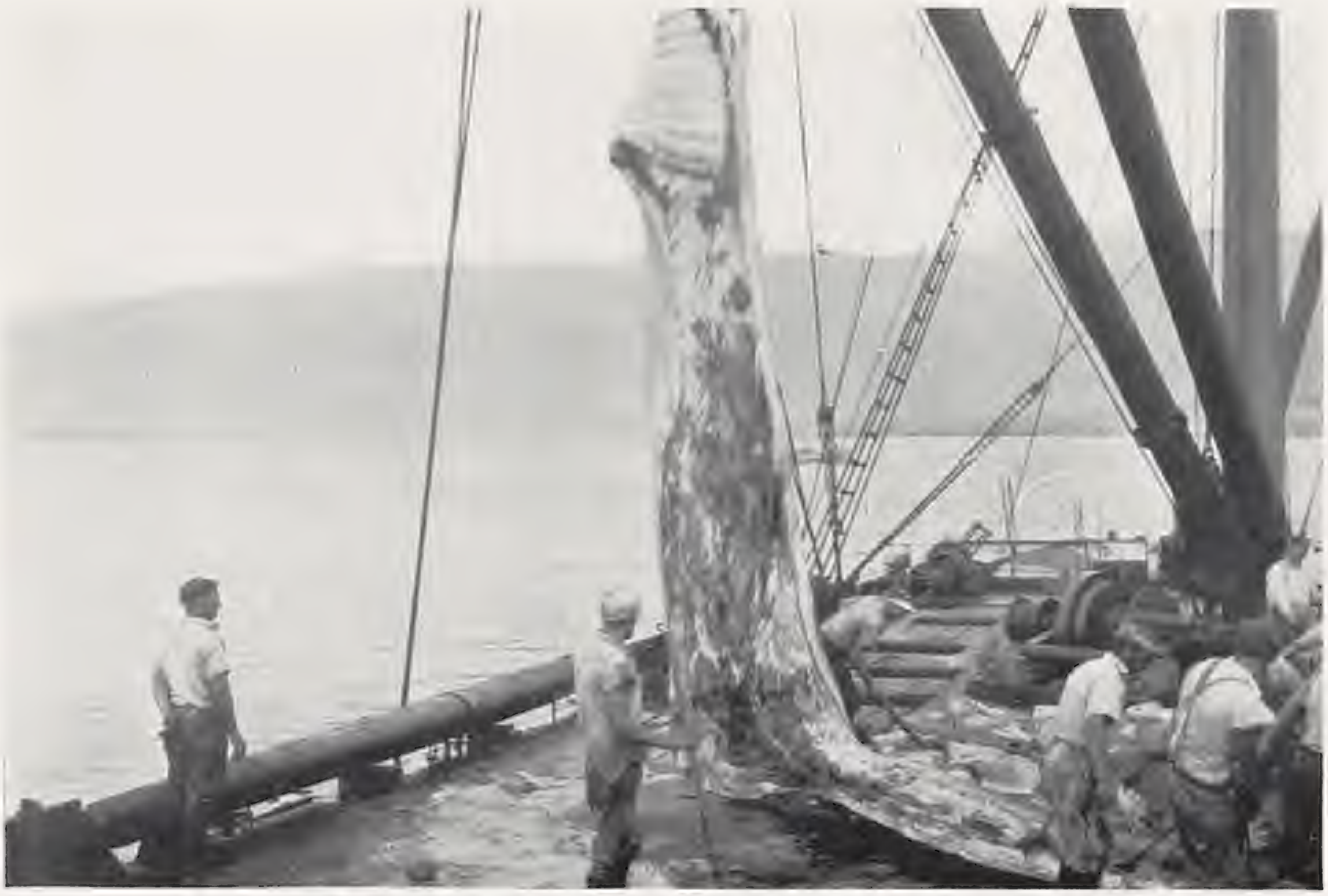
It usually took the deck crew of the *Lansing,* working with long-handled, broad-bladed knives, but half a day to dispose of a large whale and clear the deck for the next one. A motor-driven grindstone was constantly in operation for the sharpening of the axe-like knives by an expert.

The record catch for the *Lansing* was twelve whales in one day.

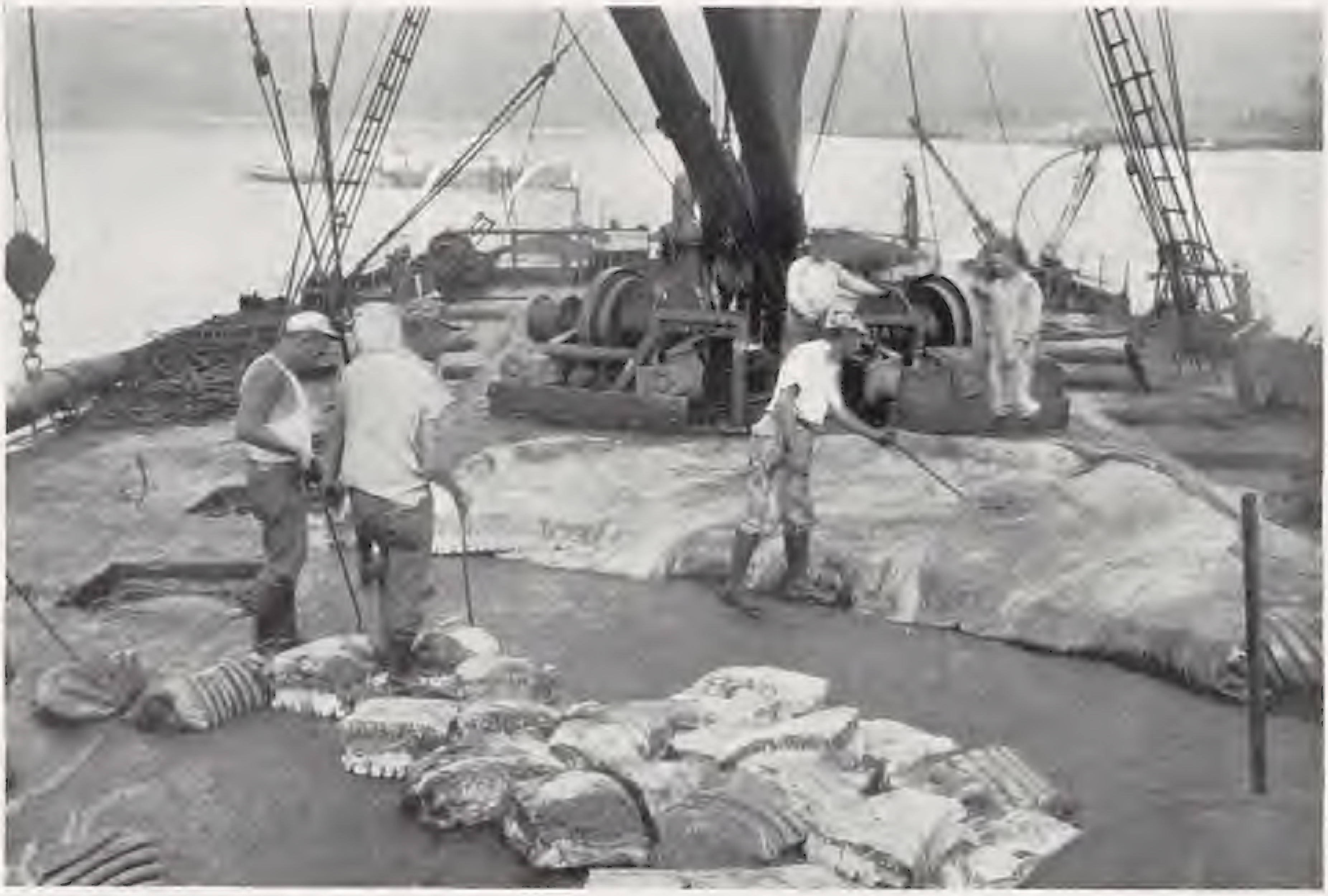
The operations for 1929 to date (October 13) were as follows: The *Lansing* left San Francisco March 16 for Magdalena Bay, Lower California, where whaling was carried on from March 28 to May 19. The next base until June 15 was at Cerros Island, L. C. The *Lansing* then operated at San Quentin Bay, L. C. from June 17 to 20, after which the vessel went to San Clemente Island, California, for the remainder of the season, concluding about the end of November.

The total catch of whales up to date of my departure on October 13 was 244, or thirty whales better than one a day. A factory steamer of this size—7,000 tons—with four hunting boats, requires about a whale a day to make a reasonable profit.

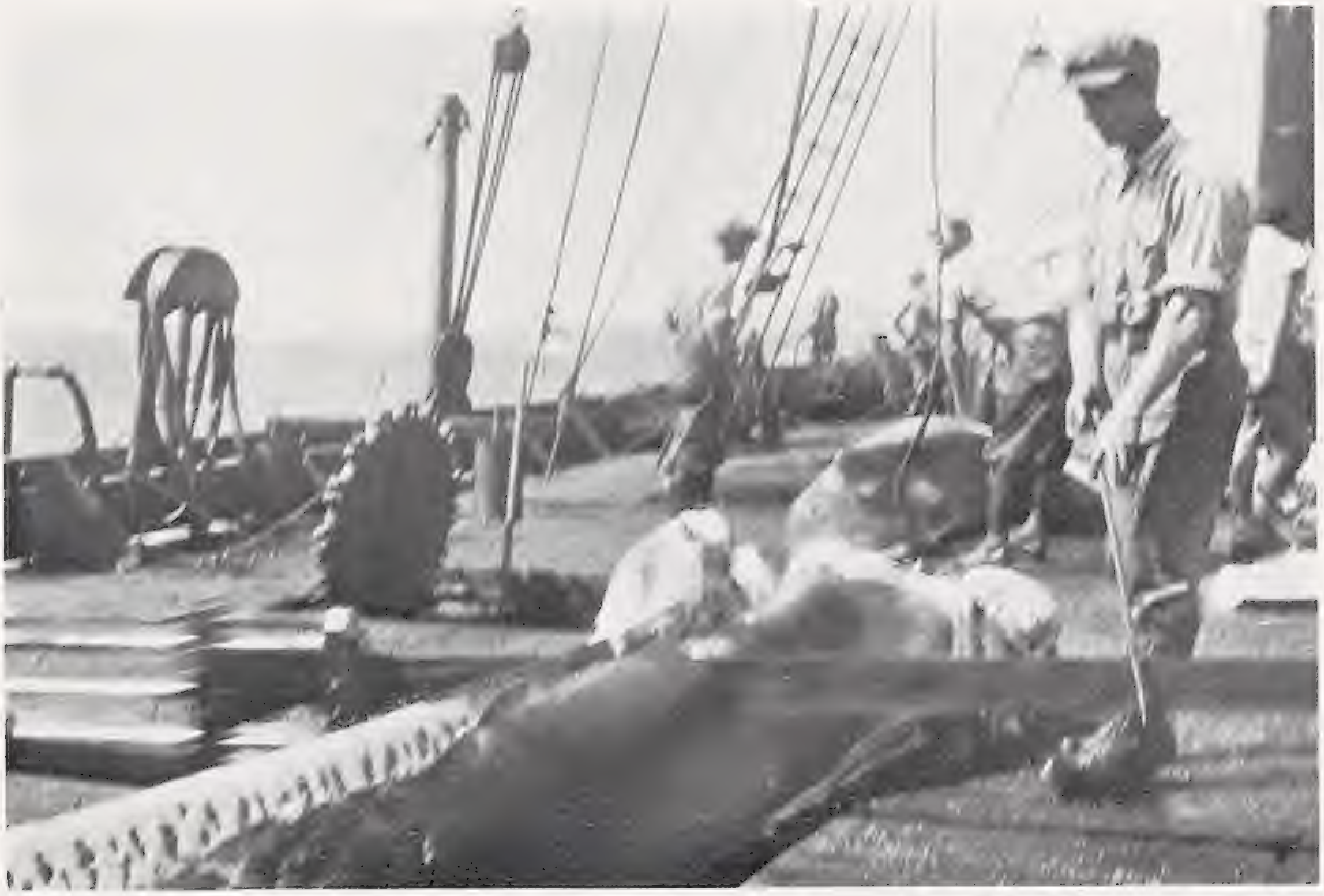
One of the hunting boats, the *Hercules,* had taken fifty-seven whales, thirty-six being blue whales. Of the total number brought to the factory ship, 145 were blue whales, eighty-one finbacks, nine humpbacks and nine sei whales. Among the blue whales there were ten per cent more females than males. The average length of the blue whales taken was sixty-eight feet, fin whales fifty-five feet, humpback forty, and sei whale thirty-eight feet. The total number of men employed on factory steamer and hunting boats is 114. The *Lansing* had in her storage tanks on October 12, 11,700 barrels of oil, worth about $26 a barrel.



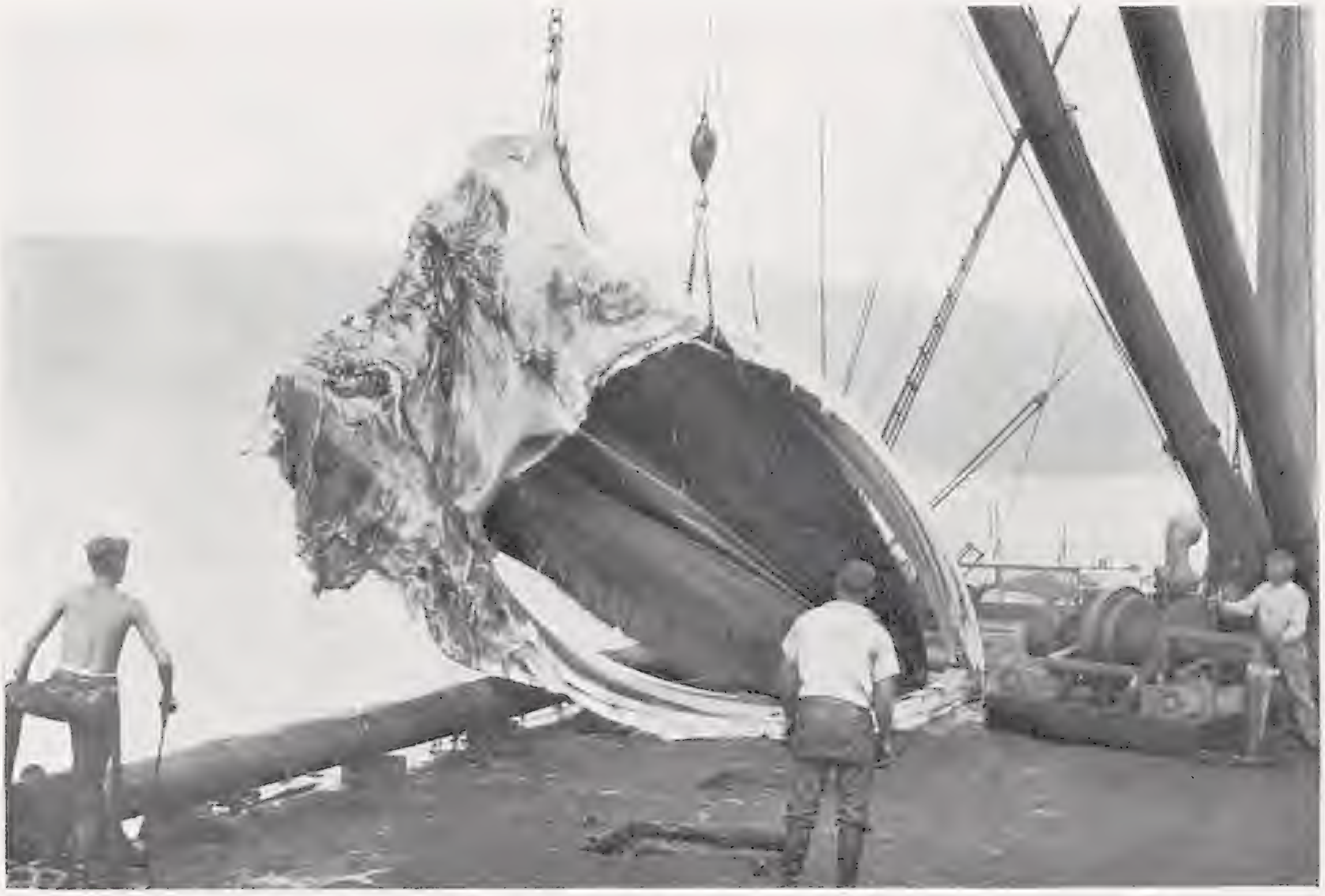
Lowering a strip of blubber on the flensing deck of the *Lansing*.



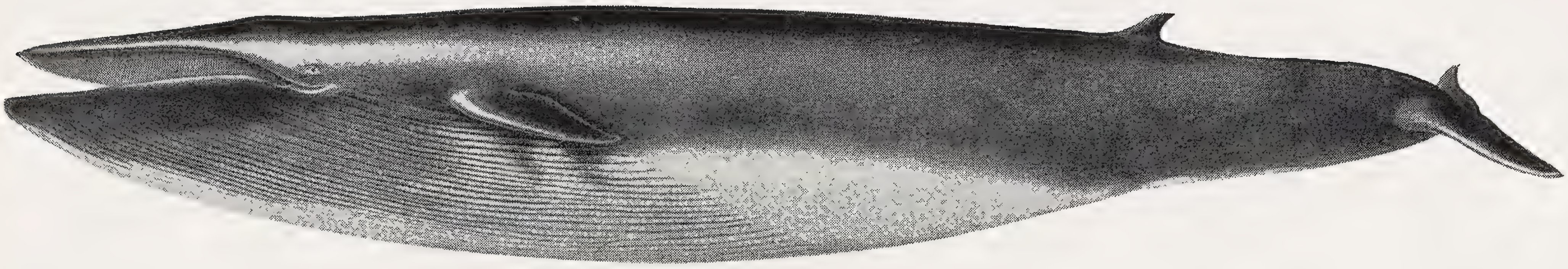
Cutting up the blubber. The pieces in foreground are ready for the digesters, the open tops of which are at each side of deck.



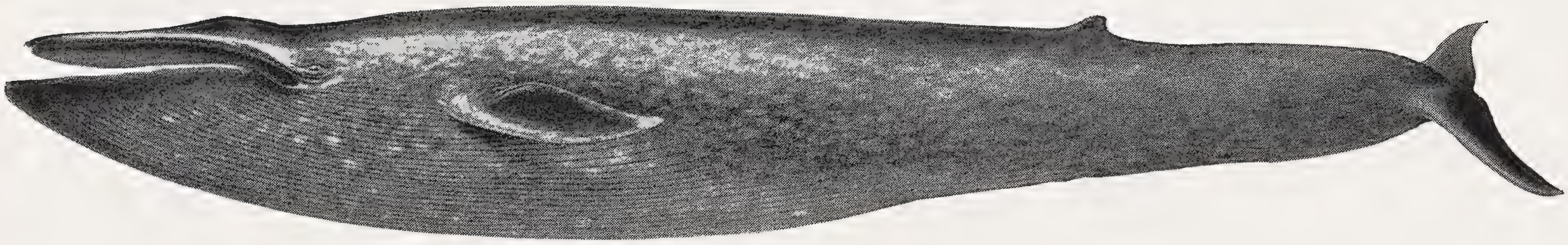
Sawing jaw bones by steam power. The bones are boiled for the oil they contain.



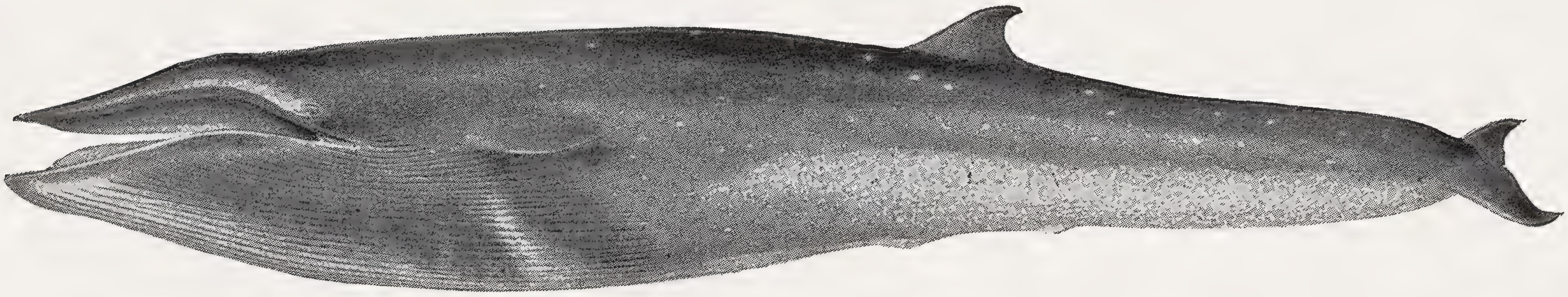
The head being lowered on deck. Observe "whalebone" on each side of upper jaws.



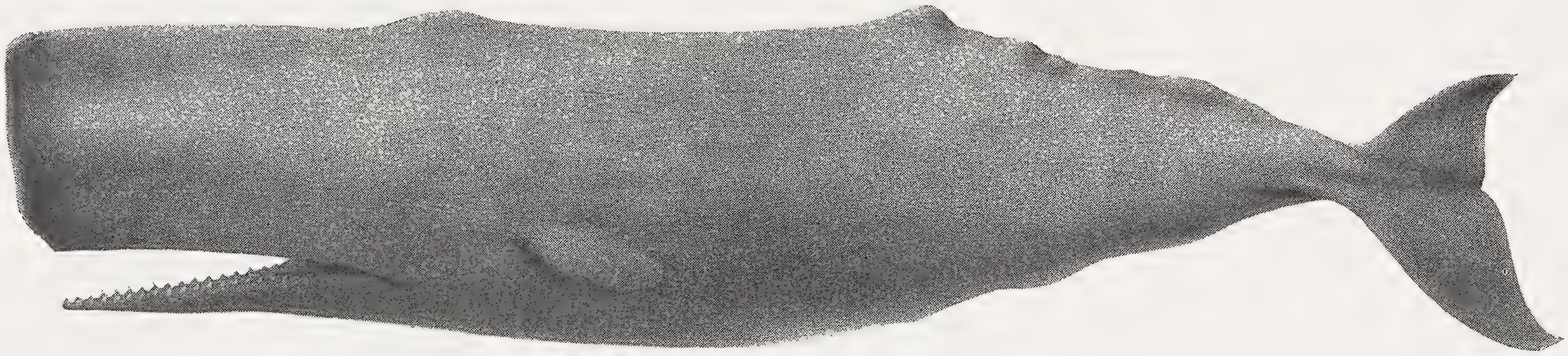
Finback whale *(Balaenoptera physalus)*



Blue whale *(Balaenoptera musculus)*



Sei whale *(Balaenoptera borealis)*

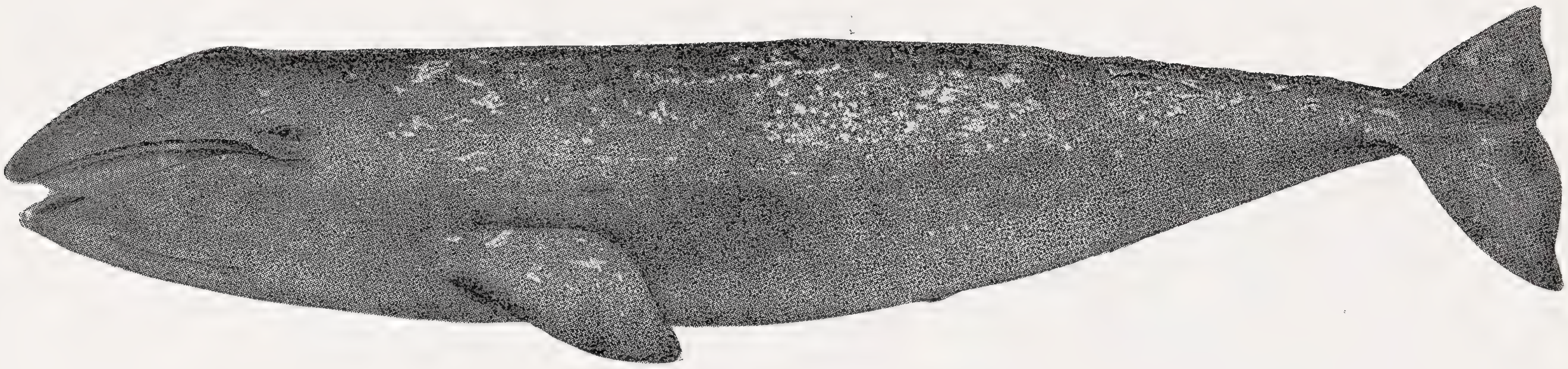


Sperm whale *(Physeter macrocephalus)*

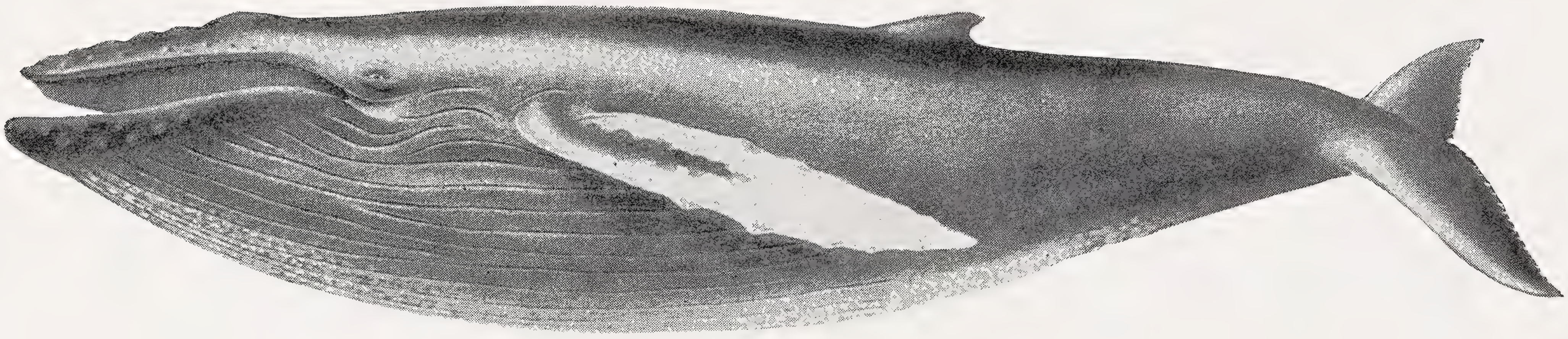
The Hunting Boats.—All of the hunting boats attached to the *Lansing* are equipped with the Svend Foyn cannon, nearly four feet long, which fires a projectile weighing about 140 pounds, exclusive of the heavy line. The bore of the gun is three and a half inches and the charge is fifteen ounces of black whaling powder. The bronze bomb driven into the whale by the line-carrying projectile is exploded as the line comes taut. Its charge is coarse black blasting powder.

The hunting boats have a speed of about nine and one half knots. Like the factory ship, all but one are oil-burners.

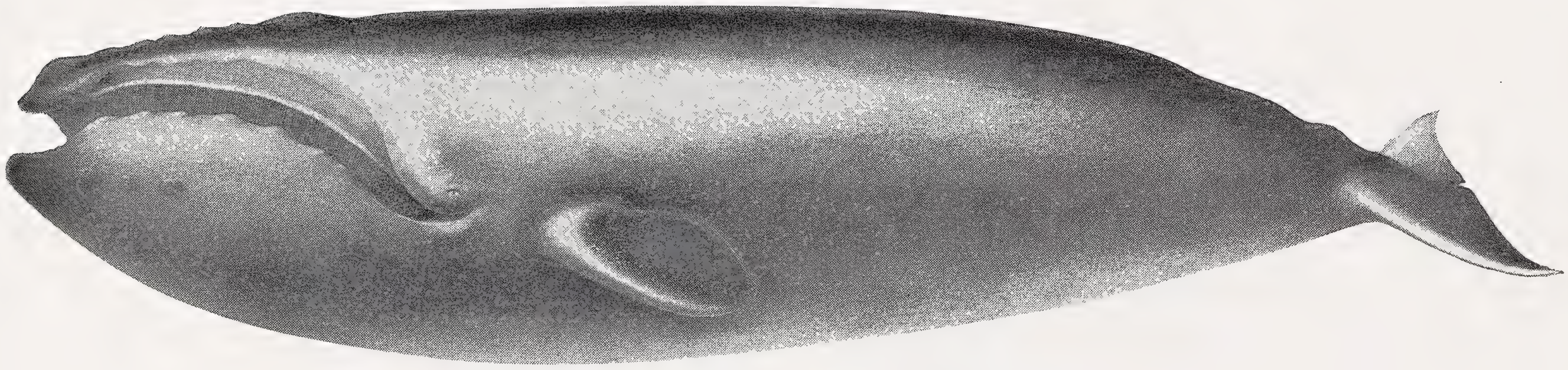
On October 11 while out with the hunting boat *Saunders,* ninety-four feet long, I observed the capture of the largest blue whale taken during my stay with the whalers. This



California Gray whale *(Rhachianectes glaucus)*



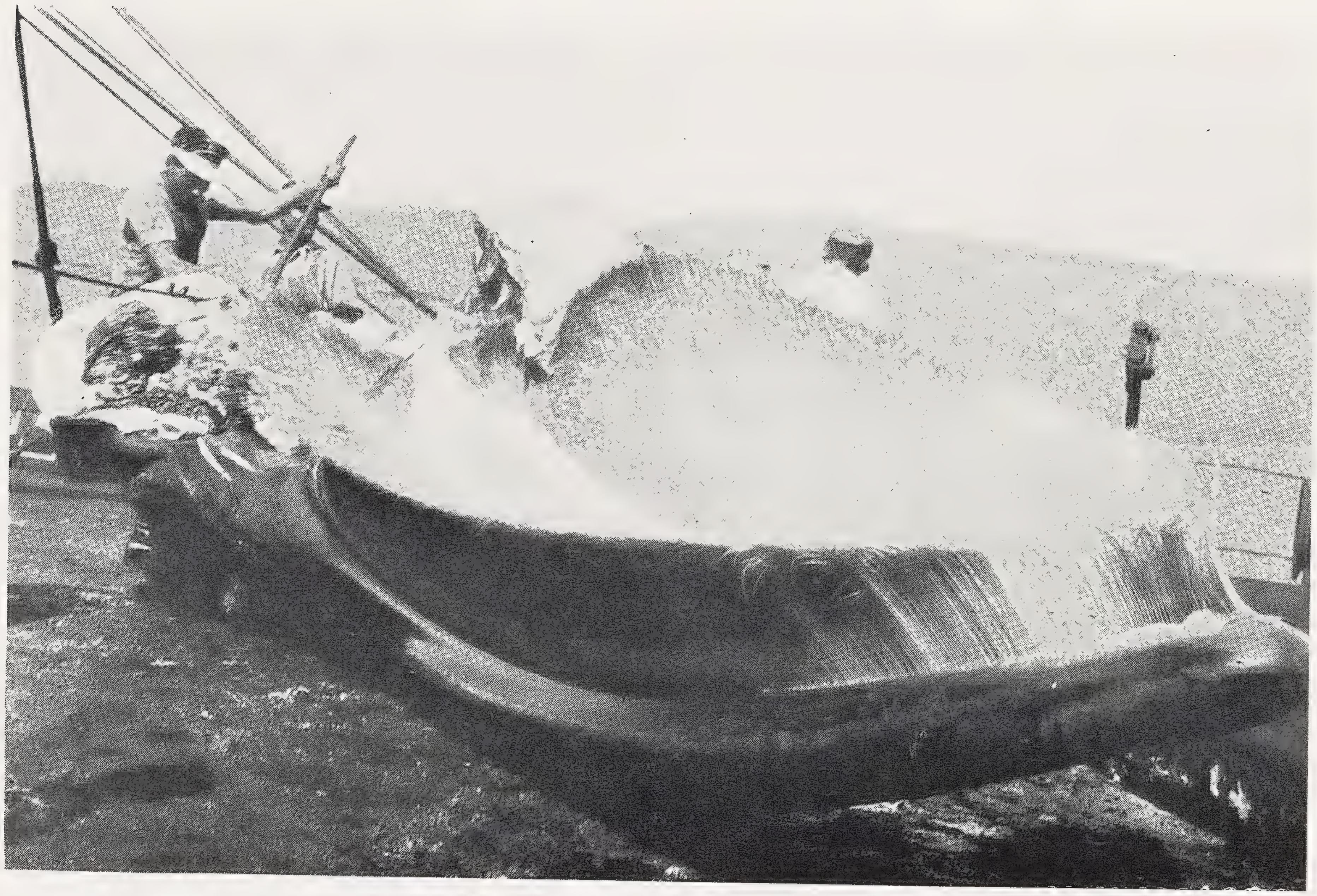
Humpback whale *(Megaptera nodosa)*



North Atlantic Right whale *(Eubalaena glacialis)*

was a female blue whale, eighty feet in length, shot at a distance of twenty fathoms (120 feet). The boat had been following a group of three whales, one a finback, for half an hour. The gunner did not get within shooting range until just after sunset. The whale was hit well forward near the fin, and its weak struggles lasted only a few minutes until it sank. The line being vertical, the gunner pronounced it dead, and the winch at once began heaving in. When brought to the surface, a tube was inserted, and the air pump started. After being inflated the whale was laid alongside, and the tail made fast near the bow. The *Saunders* was about thirty-five miles out, and did not reach the factory ship until nearly midnight.

Whales, when not quickly killed, sometimes run for an hour or more, dragging the hunting boat at high speed. A fin whale shot by the *Hercules* took out 2,500 feet and then broke



Skull, with "whalebone" or baleen. The skull is upside down, lower jaws removed.

the line. Gunners prefer to shoot at short range as the weight of the line greatly affects the trajectory. The whaling gun goes off with a cannon roar, and makes a cloud of smoke. One of the gunners told of killing a ninety-six foot blue whale off Barclay Sound, British Columbia in 1914, which measured twenty-one feet across the tail. He saw a blue whale killed off the coast of Chili in 1908, which measured 105 feet in length. The blue whale is the largest of all animals living or extinct. The fin whales I saw during a hunt with the *Hercules* seemed to blow four or five times in as many minutes before sounding, and then did not reappear for about ten minutes. They did not appear to be alarmed by the hunting boat which followed them closely in getting within shooting range.

Norwegian Whaling Investigations.—During the past decade much new information on whales and their distribution has been acquired, chiefly through the Norwegian Whalers Association. Mr. Sigurd Risting, Secretary of the Association and Editor of the Norwegian Whaling Gazette, has tabulated and analyzed the mass of statistics gathered by Norwegian whaling companies.* Many thousands of blue and fin whales have been measured at shore stations and on factory ships operating chiefly in southern whaling fields.

It is set forth that the average length of the 6,925 blue whales measured, was 24.16 metres (about 79 feet) that for every 100 females there are caught 115 males, that the largest blue whale recorded was 106 feet (33.27 metres) in length, and that only five whales exceeding 100 feet were recorded—all females.

The average length of the 5,942 fin whales that were measured was 20.66 metres (about 65 feet). For every 100 females there were caught 124 males. The largest fin whale caught was 87 feet (27.3 metres)—a female. In both species the female averages larger than the male, and both species are in general larger in southern than in northern seas.

Yield of Oil from Various Species.—The largest amount of oil recorded by Mr. Risting, 305 barrels, was from a blue whale taken in 1924 at Walvis Bay, West Africa. The average yield of oil for southern seas in general is shown to be 84.5 barrels per blue whale unit. It is smaller in temperate and northern whaling regions and this also applies to other species.

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* Whales and Whale Foetuses by Sigurd Risting (Conseil Permanent International pour L'Exploration de la Mer. Vol. 50. 1927).

The yield of oil from other species of whales taken in southern seas is much smaller than that from the blue whale, being as follows: blue whale, 84-87 barrels, fin whale 42-43 barrels, humpback 33-34 barrels, sei whale 14-15 barrels. The humpback is probably an exception as when taken in tropical or temperate seas, its oil yield is nearly as important as when taken in colder water. This is also true of the sperm whale which properly inhabits temperate and warm regions and is seldom taken in cold seas. The relative values of different species in terms of average yield of oil per whale is: one blue whale = two fin whales = two and one-half humpbacks = six sei whales in the same whaling region.

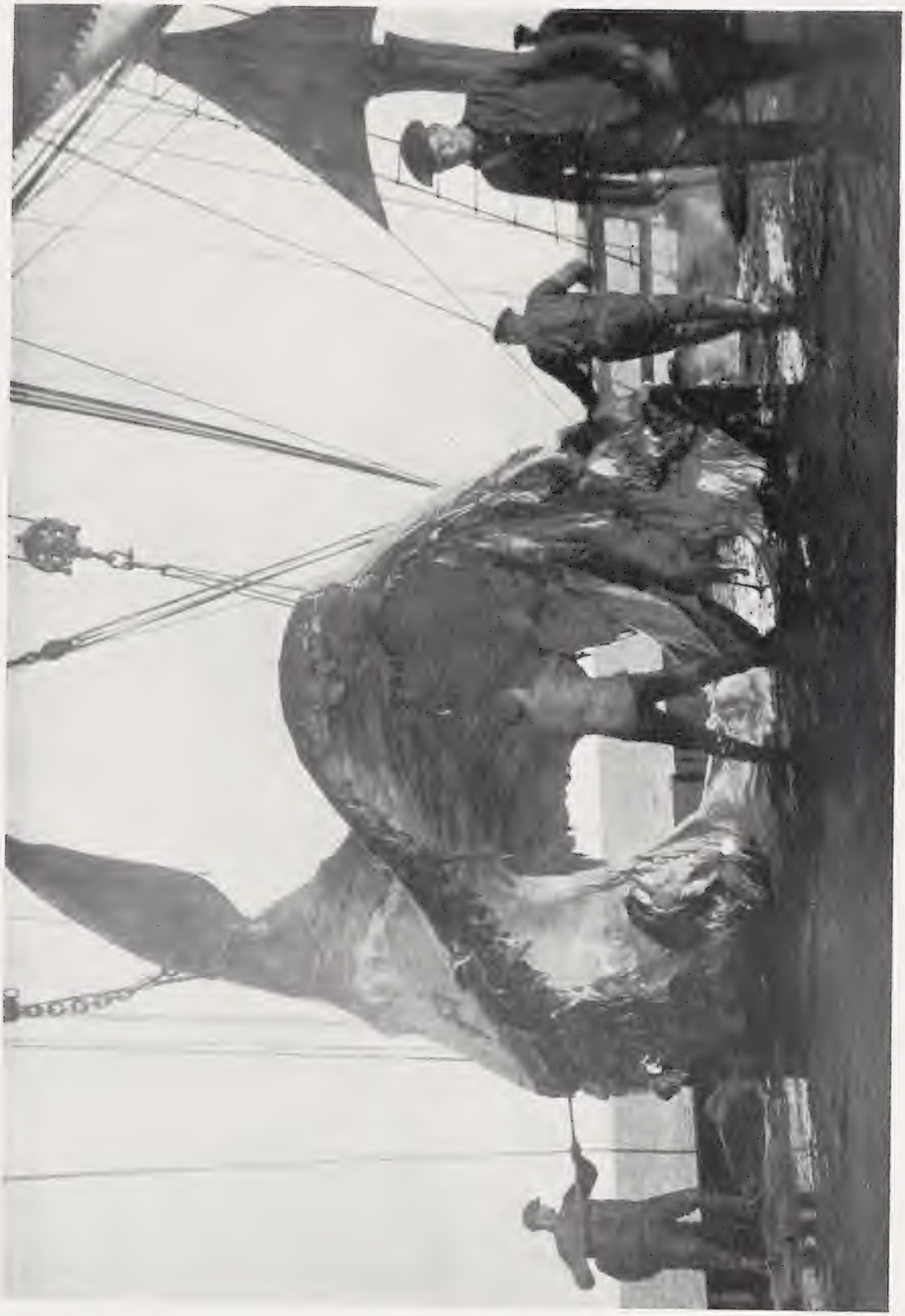
Unborn Young.—Accompanying the numerous measurements of female whales are those of foetuses. The lengthy tabulations by season, locality and size, of both mother whale and foetus yield important information on the breeding habits and movements of several species. From blue whales in southern seas, young have been taken ranging in size from one to twenty-seven feet in length. From female fin whales in the same waters, young have been found from one to twenty-one feet in length.

The tabulations dealing also with the conditions of females taken in other seas and at varying seasons, throw new light on whale migration and the period of gestation. It is difficult to make a brief summary of the hundred and twenty-two quarto pages of Mr. Risting's abundant and valuable statistics. More and more observations and measurements come with each season's whaling. The whaler's Association is thus making important contributions to science.

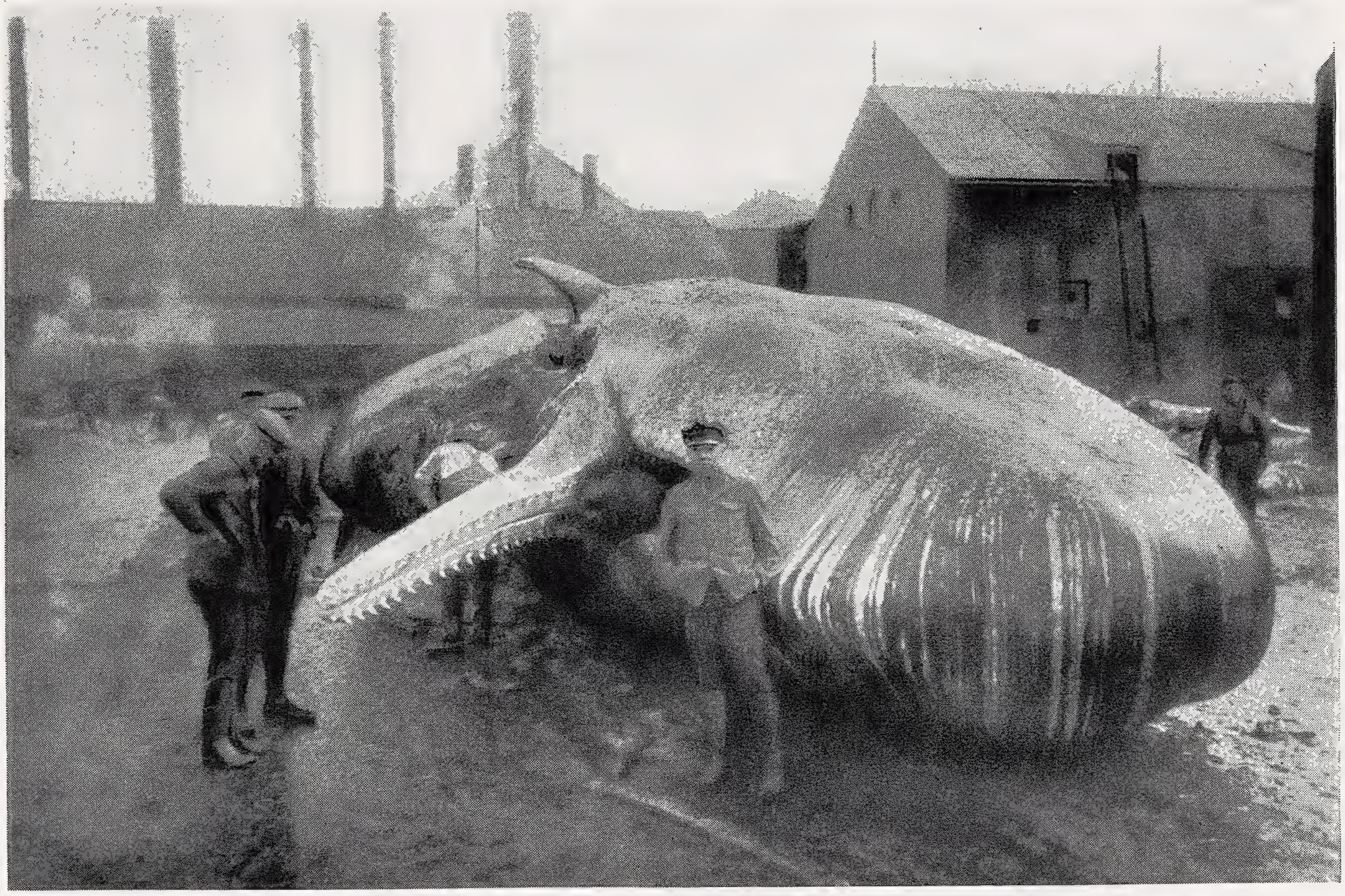
It already appears that the period of gestation is about one year, that the various species have somewhat different mating seasons, that with certain species young are born in warmer regions and during the warmer months of the year. While whales usually have but one young, there are several records of twins taken from both blue and fin whales.

Rate of Growth.—It appears that at birth the blue whale in southern seas has a length of about twenty-six feet and that it acquires a

"Whalebone" or baleen, showing arrangement of whalebone plates—
formerly valuable, now little used.



Room for Jonah. A glimpse through the body cavity.
Photo from Bryn, Sandefjord.



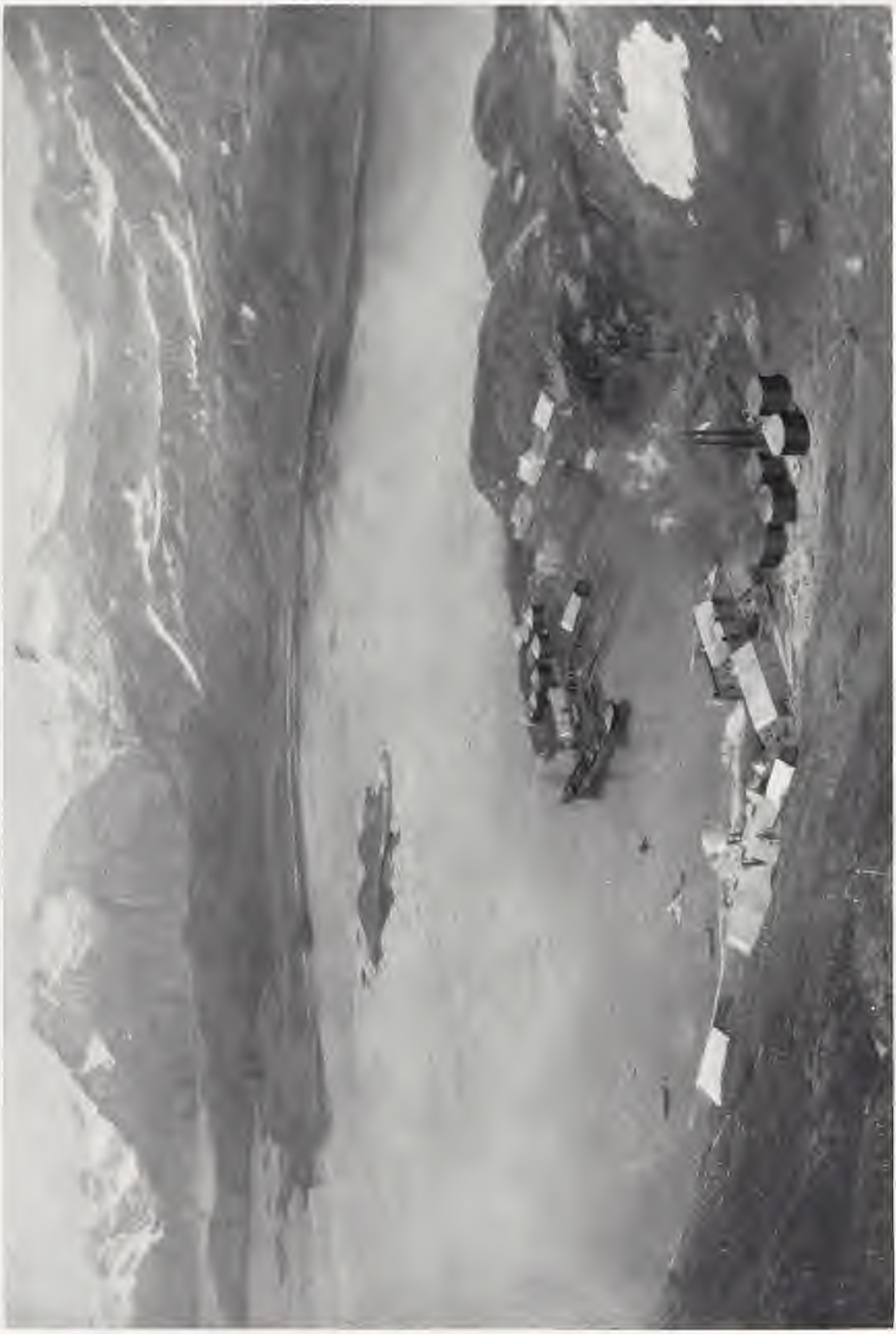
Sperm whale with mouth open. The only large whale with teeth.
Photo from Bryn, Sandefjord.

length of about sixty feet during the first year while still nursing. The period required for the blue whale to reach the breeding age cannot as yet be determined with certainty, but as gestating females are not found under the length of sixty-five feet and but seldom under seventy feet, the indications are that mating occurs during the second year. The great mass of statistics supplied by the Whalers' Association indicates that both blue whales and fin whales have young only every other year. There seems to be only one case, that of a humpback, in which a pregnant female was accompanied by a nursling. From studies of the statistics respecting all species of whales, it is evident that the rate of growth is much more rapid than was formerly supposed.

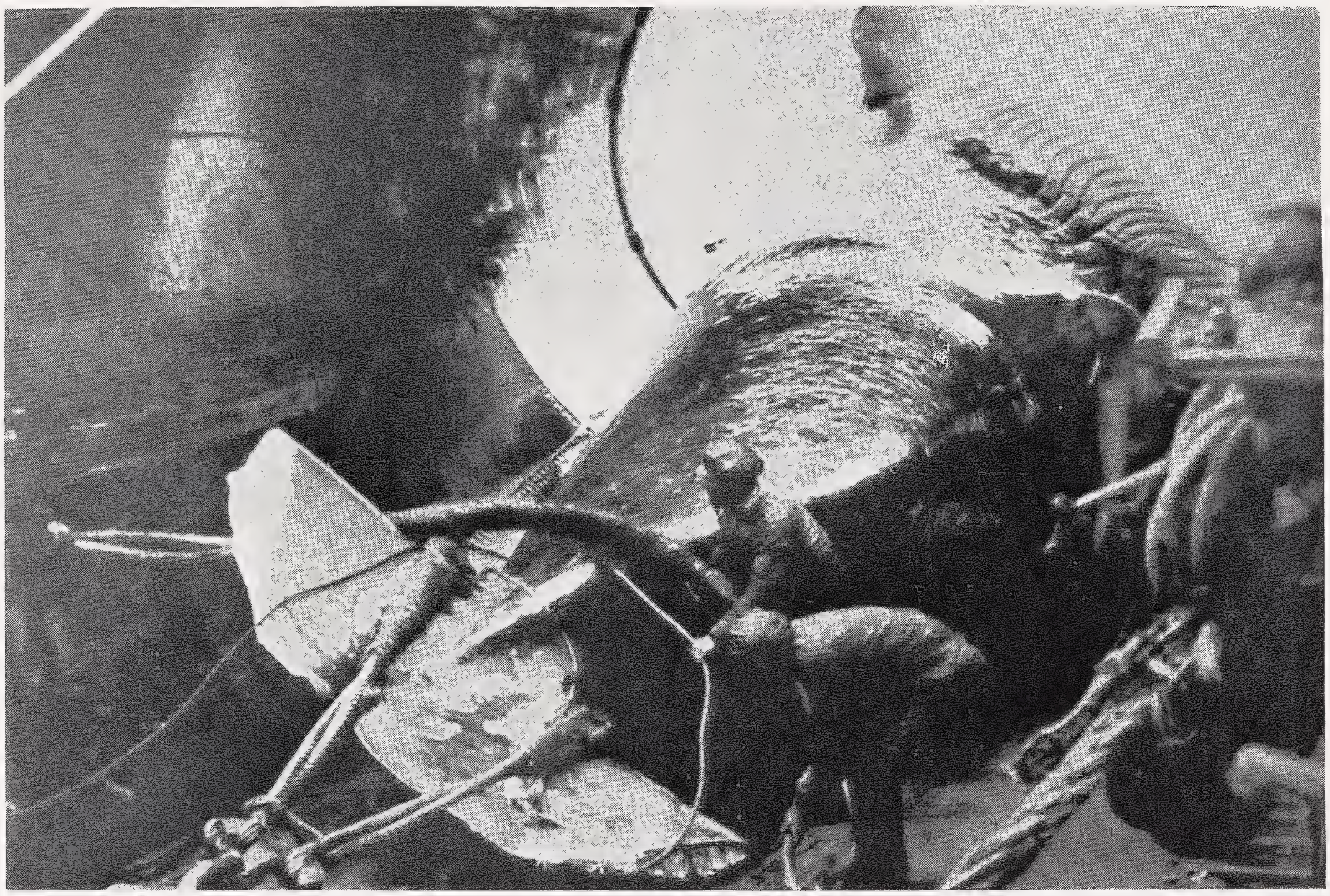
Migration of Whales.—The migratory movements of whales are connected with their breeding seasons, the young being born chiefly in temperate seas.

Their passages northward and southward are in general coastwise, the sperm whale being the principal exception. During ten years of deep sea explorations by the U.S.S. *Albatross* we saw few whales at great distances from land, as compared with the groups—sometimes large companies—seen within sight of land. There is no evidence that whalebone whales of either Arctic or Antarctic waters actually cross the tropics, although those of both regions make seasonal movements into temperate regions. The sperm whale, however, often wanders in summer into cold seas, but these are mostly males. Whalers operating from shore stations make their catches during certain seasons.

British Whaling Investigations.—The phenomenal expansion of the whaling industry in Antarctic seas has naturally attracted the attention of the British Government. The *Discovery* with a scientific staff engaged in oceanographical and whaling investigations returned to England in 1927. Similar work by the *William Scoresby* also with a scientific staff, was carried on in 1928 and 1929. The Marine Biological Station in South Georgia was reopened in 1928 and continued to the end of April, 1929. Hundreds of whales were examined as to parasites, stomach contents, breeding condition, etc. The studies included five different



In the Antarctic. Photo from Bryn, Sandefjord.



Whale being dragged on board, view from inside the "slip."
Photo from Bryn, Sandefjord.

species of whales, and reports are in preparation. More than a hundred whales have already been marked with a light dart shot into the skin, which will, on the capture of whales so marked, throw light on their development and movements. Whaling investigations are also being made by observers accompanying certain floating factories.

Whaling operations conducted at South Georgia, South Orkney, South Sandwich, and South Shetland, which are dependencies of the Falklands, are all subject to restrictions and taxes imposed by the British Government. This is also true of whaling operations about New Zealand, South Africa and other British territories.

Shore Stations.—Whaling is still carried on from land stations in many parts of the world.

We have recently acquired a great mass of statistical matter relative to both ships and shore stations now engaged in whaling. I am not yet prepared to present it in tabular form, owing to the lack of returns from several regions. Numerous shore stations have been abandoned within the past three years, while floating factories and steam hunting boats have greatly increased in numbers. While whaling operations in Antarctic seas are increasing rapidly, activities in the North have fallen off.

Our information on whaling is derived almost entirely from foreign sources, as the United States, once leader in the industry, no longer participates, except to a limited extent in California and Alaska.

An instructive compilation by Sir Sidney Harmer, chiefly from Norwegian and British data, will serve the purpose of the present article. It shows the extent and distribution of the whaling industry in 1925-26. (See page 24.)

Whale Conservation.—The Whaling Committee of the International Council for the Exploration of the Sea which recently met in London, considered the subject of whale conservation. The general feeling of the Committee was that, although it is not at present possible to put forward recommendations which can be said to have a strictly scientific foundation, nevertheless it "feels strongly that the enormous expansion of the whaling industry in recent years constitutes a real menace to the

Whaling data for these regions, including also British Columbia, are presented in the following tables. (From *Norwegian Whaling Gazette,* April, 1929.)

Pacific Coast Whaling Products, 1928.

District	No. Plants Operated	No. Whales Taken	Whale and Sperm Oil Gallons	Guano Tankage, Tons	Bone Meal, Tons
Alaska	2	402	824,400	849	477
British Columbia	2	305	622,050	732	376
California	*1	304	630,000	...	...
	5	1,011	2,076,450	1,581	833

* Floating factory *Lansing.*

Pacific Coast Whaling Products, 1918-1928.

Year	No. Stations Operated	No. Whales Taken	Whale & Sperm Oil, Gallons	Guano Tankage, Tons	Bone Meal, Tons	Baleen, Tons
1918	8	1,137	1,892,550	2,350	9,250	..
1919	8	1,436	2,648,204	3,450	14,000	..
1920	10	1,763	2,722,971	3,475	1,015	59
1921	1	129	209,392	219	129	..
1922	7	1,356	2,392,250	3,075	1,057	7
1923	8	1,363	2,260,200	2,944	1,147	30
1924	7	1,102	1,934,450	2,428	826	5
1925	7	989	1,802,500	2,211	647	..
1926	6	988	1,705,186	1,906	906	19
1927	7	1,360	2,151,950	1,472	911	32
1928	5	1,011	2,076,450	1,581	853	..
Total		12,634	21,796,103	25,111	30,741	142

Note:—Above tables include production of companies operating from the United States and Canadian ports on the Pacific. All figures prior to 1927 represent products from shore stations.

World-Production, 1925-26 (Southern Seas) and 1926.

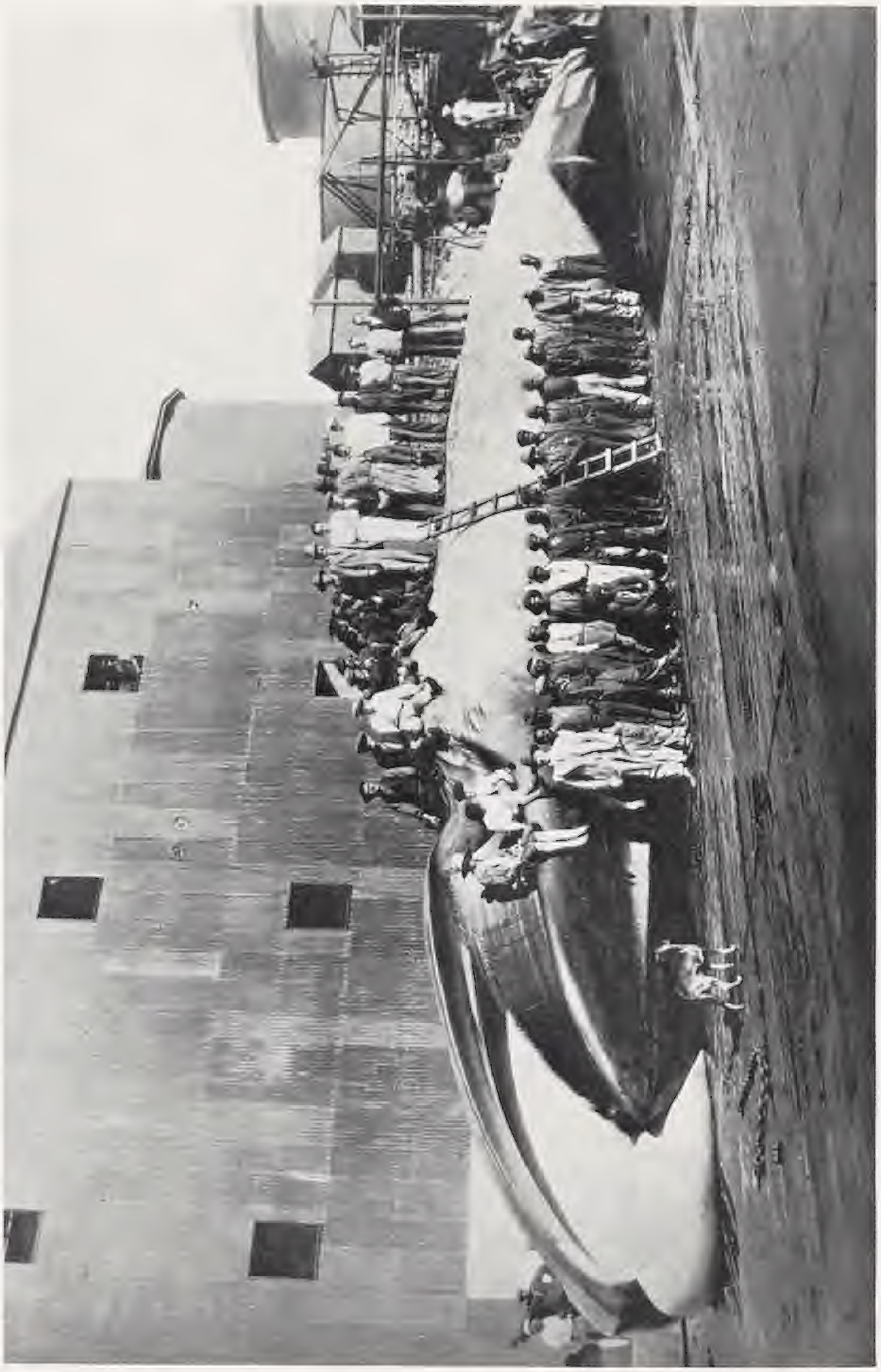
Locality	Barrels of Oil	Number of Whales	Barrels of Oil, Average per Whale
A. Antarctic Area.			
1. South Shetlands.			
Norwegian Companies	208,890	4,746	62.0
Other Companies	85,450		
2. South Georgia.			
Norwegian Companies	188,491		
Other Companies	212,656	7,819	51.3
3. South Orkneys	27,050	623	43.4
4. Ross Sea (*Sir J. C. Ross*)	39,630	566 *est.*	70.0
5. South Sea (*Lancing*)	17,000	243 *est.*	70.0
B. Africa.			
1. Cape Colony	60,892	2,238	27.2
2. Natal	46,084	1,238	37.2
3. Walfisch Bay	13,200	375	35.2
4. French Congo	12,294	402	30.1
5. Other African localities ca.	6,000	286 *est.*	21.0
C. Australia and New Zealand.			
Australia	22,000	550 *est.*	40.0
New Zealand	No record		
D. South Pacific.			
1. Chili	15,250	429	35.5
2. Peru	19,500	542 *est.*	36.0
3. Ecuador	9,000	371	24.3

E. NORTH PACIFIC.			
1. Mexico, Mexico Co.	14,326	422	33.9
"Vega" Co.	14,861	394	37.7
2. California	4,860	136	35.7
3. British Columbia	12,900	269	48.0
4. Alaska	20,200	803	43.2
5. Kamchatka	11,586	283	40.9
6. Japan and Korea	25,000	1,281	19.5
F. NORTH ATLANTIC.			
1. Grenada, W. Indies	2,500	72	34.7
2. Newfoundland	11,600	290 *est.*	40.0
3. Spain, Corcubion		625	
Spain, Gibraltar	26,938	300	29.1
Spain, Soc. Esp. Corona	10,500	350 *est.*	30.0
4. Portugal	7,000	278	25.2
5. British, Harris	5,500	212 est.	26.0
British, Shetland	6,879	269	25.6
6. Faeroe Is., Norwegian Co	1,282	42	30.5
Faeroe Danish Co	3,512	129	27.2
7. Norway, W. Coast			
Norsk Hvalfangst	4,671	206	22.7
Aukra Hval Co	4,295	185	23.2
Brodr. Saebjornsen	1,950	89	21.9
Winge, Blomvaag	2,144	94	22.8
8. Spitsbergen ca.	1,000	25 *est.*	40.0
	1,181,891	26,962	43.8
S. Shetlands, S. Georgia			
S. Orkneys	779,167	13,997	55.7
Ross Sea, South Sea			
(*Lancing*)			
All other localities	402,724	12,965	31.1
	1,181,891	26,962	43.8
Norwegian Companies	655,608		
Other Companies	526,283		
	1,181,891		

The numbers and kinds of whales taken in the Antarctic from 1910 to 1927 have been presented in the following table, also compiled by Harmer chiefly from Norwegian and British sources:

TOTAL CATCHES, ANTARCTIC AND SOUTH AFRICA

	Right Whale	Sperm Whale	Blue Whale	Fin Whale	Hump-back	Sei Whale	Bryde's Whale	Bottle-nose	Total
South Georgia									
1909-10	37	4	26	58	3,391	..	..	..	3,516
1910-11	79	..	85	168	6,197	..	..	..	6,529
1911-12	82	4	298	516	5,635	..	..	..	6,535
1912-13	6	9	317	2,157	2,360	1	..	(1)	4,850
1913-14	66	21	940	1,716	512	94	..	..	3,349
1914-15	20	1	2,313	1,940	823	..	..	..	5,097
1915-16	12	1	3,026	2,744	1,578	..	..	..	7,361
1916-17	12	35	2,440	1,606	378	..	..	..	4,471
1917-18	35	37	1,871	1,144	60	49	..	..	3,196
1923-24	..	46	1,926	1,375	131	195	..	..	3,673
1924-25	..	24	3,514	2,017	262	1	..	..	5,818
1925-26	..	15	1,845	5,713	237	9	..	..	7,819
1926-27	..	17	3,670	1,147	..	370	..	..	5,204



"Leviathan, which God of all his works created hugest that swim the ocean stream"—*Milton.*
Photo from Bryn, Sandefjord.

South Shetlands									
1911-12	17	..	892	1,727	2,174	..	..	3	4,813
1912-13	3	..	1,761	2,300	976	..	..	4	5,044
1913-14	3	..	1,472	2,092	977	..	..	..	5,259
1914-15	2	..	1,796	1,679	656	..	..	..	4,133
1915-16	6	3	1,845	2,358	219	..	..	..	4,431
1916-17	..	..	1,380	602	21	..	..	..	2,003
1917-18	13	..	397	627	71	6	..	..	1,114
1923-24	12	19	1,369	1,559	98	2	..	2	3,061+3
1924-25	..	42	1,642	1,948	100	..	..	..	3,732
1925-26	..	29	2,157	2,390	165	4	..	1	4,746
1926-27	..	23	1,275	3,442	94	2	..	2	4,838
South Orkneys									
1923-24	..	..	210	82	3	..	..	..	295
1924-25	..	..	189	314	4	..	..	..	507
1925-26	1	1	44	573	4	..	..	..	623
1926-27	..	..	284	301	4	..	..	..	589
Cape Colony									
1923	1	30	669	460	13	128	11	..	1,312
1924	..	34	505	570	19	367	51	..	1,546
1925	..	60	783	694	9	21	12	..	1,579
Natal									
1923	..	73	210	331	106	63	..	.	783
1924	2	256	169	353	187	56	..	..	1,023
1925	..	511	240	254	167	112	..	..	1,284
1926	1	466	214	336	124	97	..	..	1,238
1927	..	408	220	287	84	89	1	..	1,089
	410	2,169	41,994	47,580	27,839	1,666	75	13	122,463

The following table, incomplete as to numbers of whales, shows the important part taken by Norway in the whaling industry:

WHALE FISHERY IN JAPAN.*

Year	Right Whale	Finback	Sei	Hump-back	Blue	Sperm	Gray	Total
1910		208	48	8	38	67	91	460
1911	2	975	375	59	243	163	123	1,940
1912	3	743	236	68	236	107	193	1,586
1913	1	839	361	138	58	77	131	1,605
1914	1	1,040	239	160	123	304	155	2,022
1915	7	817	723	105	57	252	139	2,100
1916	8	739	419	93	75	391	78	1,803
1917	2	745	581	32	75	195	66	1,696
1918	2	697	739	20	24	588	104	2,174
1919	5	522	532	52	53	461	46	1,671
1920	4	320	221	80	28	127	25	805
	35	7,645	4,474	715	1,010	2,732	1,051	17,862

The most recent information at hand on Japanese whaling relates to the year 1925 when the number of whales taken was 1,588.

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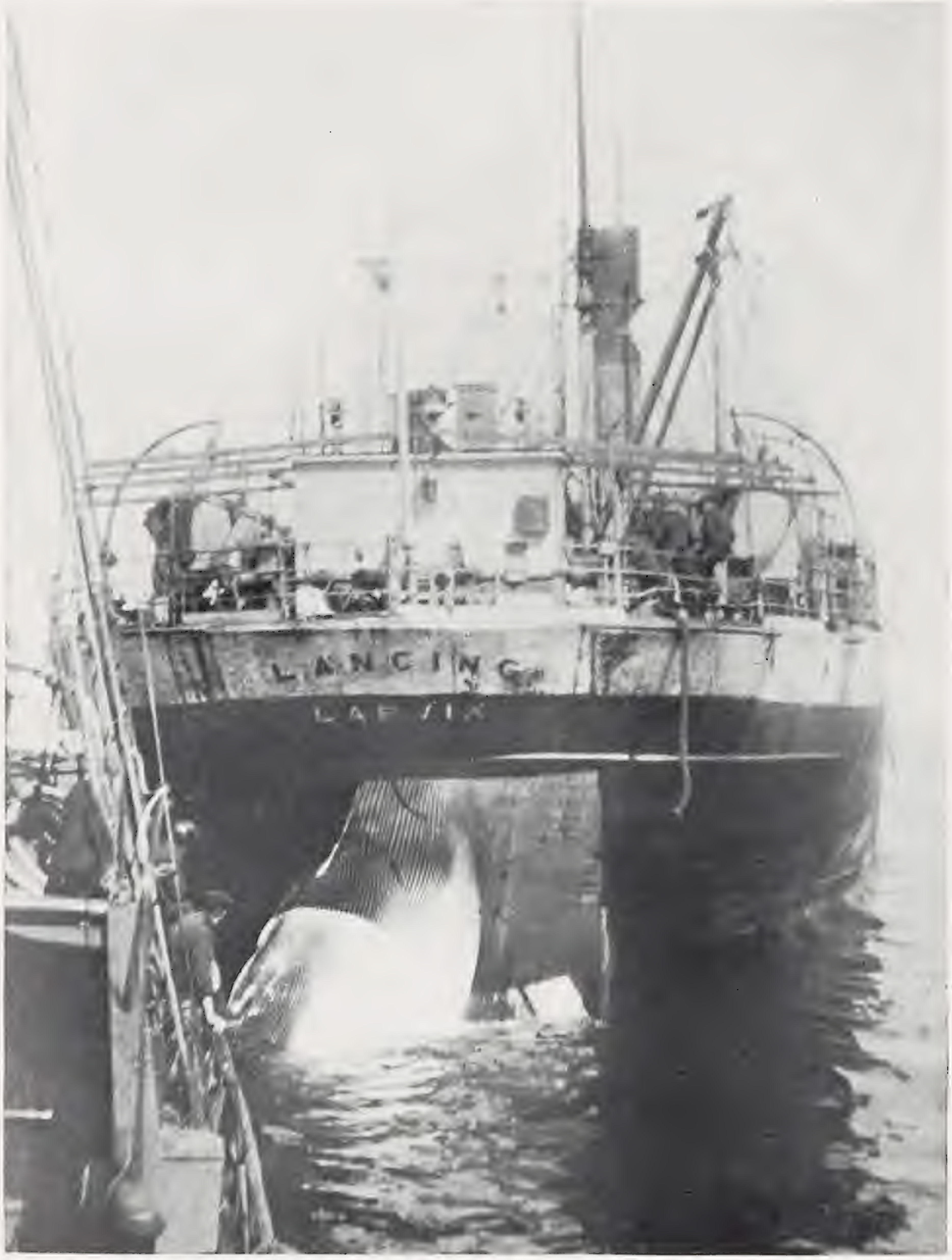
* K. Togo, Whales in Japanese Waters.



Pulling the whale on board. The larger factory ships have "slips" for this purpose.
Photo from Bryn, Sandefjord.

Development of Norwegian Whaling

From 1906 to 1928*

Year	No. of Companies	Hunting Boats	Shore Stations	Floating Factories	No. of Whales	Barrels of Oil	Value (Kroner)†	Value Dollars
1906	21	52	14	7	1,778	51,400	3,075,000	$768,750.00
1907	22	55	14	9	2,324	65,250	4,400,000	1,100,000.00
1908	23	62	15	9	2,569	69,000	3,500,000	875,000.00
1909	27	72	19	9	5,318	128,700	5,925,000	1,481,250.00
1910	31	83	22	14	6,927	183,900	11,950,000	2,987,500.00
1911	43	106	26	27	13,800	344,000	22,000,000	5,500,000.00
1912	60	161	34	39	14,500	479,000	4,600,000	1,150,000.00
1913	54	160	30	36	18,000	600,000	36,000,000	9,000,000.00
1914	50	149	23	36	14,800	575,000	36,000,000	9,000,000.00
1915	29	94	15	20	10,000	475,000	32,000,000	8,000,000.00
1916	18	57	11	10	8,230	367,000	32,000,000	8,000,000.00
1917	8	29	4	5	4,400	231,000	31,000,000	7,750,000.00
1918	8	44	8	5	3,300	147,000	28,000,000	7,000,000.00
1919	8	42	8	5	3,478	163,750	33,000,000	8,250,000.00
1920	17	54	15	5	4,582	212,000	60,000,000	15,000,000.00
1921	11	39	6	7	6,427	281,400	36,000,000	9,000,000.00
1922	15	50	9	9	6,321	338,000	45,000,000	11,250,000.00
1923	21	73	13	12	8,550	440,000	63,000,000	15,750,000.00
1924	22	84	13	14	7,450	382,300	65,000,000	16,250,000.00
1925	26	103	15	17		581,000	90,000,000	22,500,000.00
1926	29	107	16	18		655,608	75,000,000	18,750,000.00
1927	28	116	15	18		704,000	60,000,000	15,000,000.00
1928	21	89	10	15		845,884	68,000,000	17,000,000.00
———			Totals		142,754	8,320,192	845,450,000	211,362,500.00

* Norwegian Whaling Gazette, March, 1929.

† Present value of Kroner, 25 cents.

maintenance of the stocks of whales, and that if the expansion continues at the present rate there is a real risk of those stocks being so reduced as to cause serious detriment to the industry." The report admits that until scientific researches have reached a definite conclusion, it is impossible to devise permanent measures of protection, but the Committee thinks that the governments of the countries interested should, as a matter of urgency, seriously consider taking immediate temporary measures to deal with the menace. Among the measures suggested is the prohibition of killing certain species of whales, principally right whales, the protection of cows with calves, immature whales, and the prohibition or restriction of the capture of whales in certain regions, notably in the tropics.

Under a new act by the Norwegian parliament* all Norwegian whalers are forbidden to kill the right whale, and all whale cows with calves. The practice of paying whaling crews according to the number of whales taken must be discontinued, and all parts of the animal containing oil must be utilized. Penalties are provided and the King is empowered to forbid whaling in tropical waters.

Some form of protection for females accompanied by young should, of course, be afforded. The cessation of whaling in waters where the young are born is desirable.

The pelagic sealing industry which reduced the great fur seal herds to a paltry hundred and fifty thousand, was destined to break down as it did, because it was based chiefly on the killing of female seals. These were taken largely in the Bering Sea, adjacent to the Pribilof and Commander Islands. It involved not merely the loss of mother seals feeding at sea, but the loss by starvation of equal numbers of nursing young on the islands. It was a part of the writer's duty to enumerate these losses on the Pribilofs during the early nineties.

In discussing with Norwegian and Californian whalers the increasing drain upon the stocks of whales, I found but one opinion expressed: The cost of operating factory steamers and their numerous hunting boats, is so great that when the supply of whales falls below the number required daily for profitable operations, they would be forced out of business until whales again become abundant.

It should be borne in mind, however, that the various species do not exist in equal numbers.

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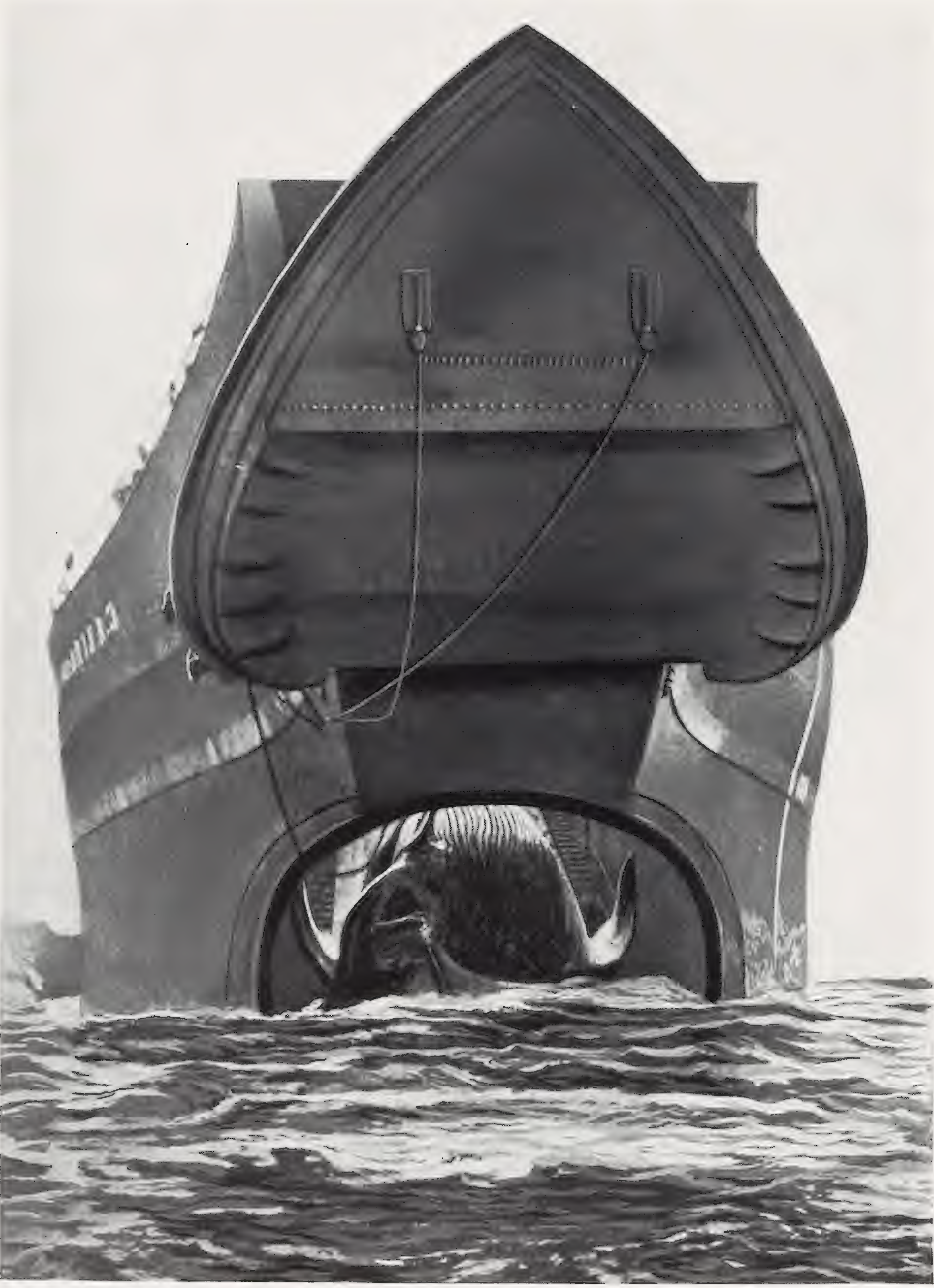
* Law of June 21, 1929.



A ship that swallows whales. The slip in the bow of the floating factory *C. A. Larsen,* through which whales are drawn on board. All the larger whaling steamers handle whales in this manner. Courtesy *The Illustrated London News.*

Care should be taken that the rarer whales are not unduly reduced in numbers. Naturalists attribute the extinction of certain birds and mammals to over exploitation, which brought them to a point where their natural enemies, internal and external, overcame their powers of increase. This has happened frequently with animals of restricted distribution. Steller's sea cow and the great Pallas cormorant are notable cases in point. Both were restricted to the Commander Islands, and were used for food.

Whales have a widely distributed enemy in the killer (*Orca*) which hunts in packs.* The killer, twenty-five or thirty feet in length, is active and savage, attacking whales, porpoises and seals. R. C. Andrews observed that a large proportion of the whales taken at Japanese shore whaling stations had been mutilated by killers.

Acknowledgments.—The writer is indebted to many persons engaged in the modern whaling industry for information on this subject. Among these are Mr. Gunnar Isachsen of Asker, Norway; Mr. T. H. Poulsson of Tonsberg, Norway; Captain F. K. Diedrick, General Manager of the California Sea Products Company of San Francisco; and Captain C. Swanson of the factory steamer *Lansing*. To Mr. Charles R. Patterson of New York, artist, navigator and observer of whaling operations in British Columbia, he is indebted for permission to reproduce his painting of the killer whale. The writer has made free use of the Norwegian Whaling Gazette, and a copy of Whales and Whale Foetuses supplied by Mr. Sigurd Risting of Sandefjord, Norway. Mr. Bryn, photographer, of Sandefjord, Norway, has supplied certain photographs illustrative of modern whaling methods. It would have been difficult to reach the factory ship *Lansing,* had not the officers of the California State Fisheries Laboratory at Terminal Island kindly furnished transportation to San Clemente Island on the Fisheries patrol boat *Albacore*. Dr. T. S. Palmer of Washington has supplied the table showing the catch of whales in Japanese waters from 1910 to 1920. Grateful acknowledgment is made to Dr. H. M. Wegeforth of San Diego, for the opportunity of visiting the herd of Elephant seals at Guadalupe Island.

The Northern Elephant Seal Herd in 1929

CHARLES HASKINS TOWNSEND

IT is gratifying to be able to report that this species—largest of all seals, and now found only on Guadalupe Island, Lower California, is increasing in numbers.

A careful count made at Guadalupe Island on September 27, 1929, showed that there were on the beach 469 of these animals. These were seals of varying sizes from young of the year to adult males and females. An inspection of the different groups showed that they were composed chiefly of immature animals. The relative scarcity of seals of adult size was probably due to the fact that the breeding season, beginning about March first, was long past. The young of the year had already lost the black color of the nursing pup.

The Guadalupe herd of elephant seals when visited by the writer in March, 1911,† consisted of about 150 animals, as based on counts of adults and young present, and estimates of intermediate sizes assumed to be absent from the rookery. Since 1911 the seals of Guadalupe Island have been protected by the Mexican government.

It is possible that the number of animals present on September 27, 1929, represents but half of the herd belonging there. It is certain that the number of breeding adults was far short of those seen there in March, 1911. There was no evidence that the herd had been disturbed, as the seals were as little concerned about our presence among them as during our visit eighteen years before, when they were altogether fearless.

During the past year a few large elephant seals have been observed at sea as far north as the latitude of San Diego, California, where one was killed by fishermen in September, 1929. This seal, a large male, is now in the Museum of Natural History at San Diego. An examination of its stomach contents showed

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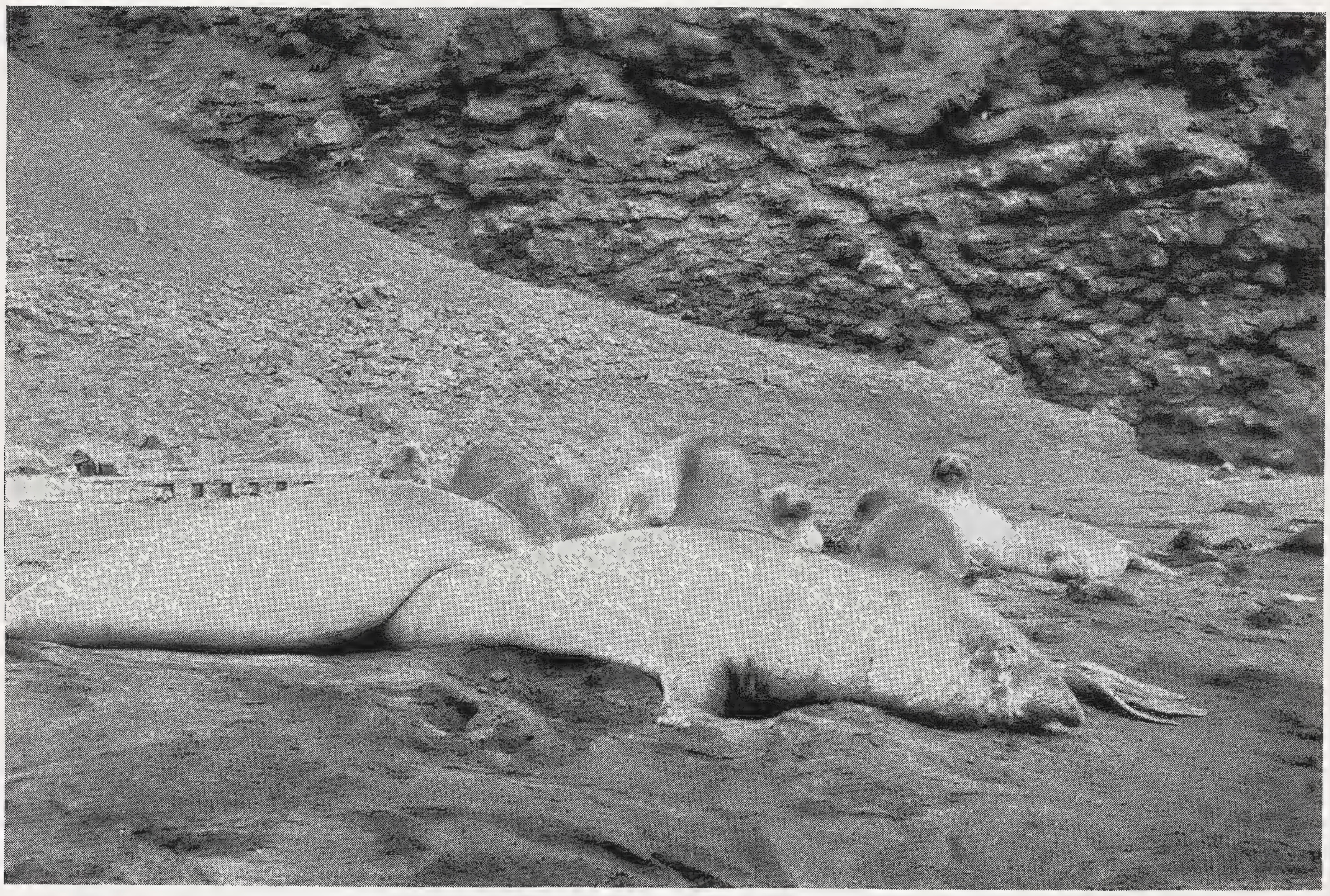
* See frontispiece.

† The Northern Elephant Seal. C. H. Townsend. Zoologica. April 15, 1911.



Elephant seals, Guadalupe Island. Young animals of various ages.

that it had been feeding on fishes, one of which was a skate.

The expedition of 1929 was suggested by Dr. H. M. Wegeforth, President of the San Diego Zoological Society. Through the co-operation of Commander G. H. Bowdey, U. S. N., of the Eleventh Naval District, a Naval Reserve cruiser was detailed for the voyage.

The party consisted of naval officers and several naturalists, including the writer. By permission of the Mexican Government, four large male elephant seals were captured without injury, and taken to the San Diego Zoological Gardens.

◆

Guadalupe Fur Seal in 1929

Charles Haskins Townsend

ONE of the objects of the party which I accompanied to Guadalupe Island was a search for the fur seal (*Arctocephalus townsendi*) formerly abundant in the Lower California region. In May, 1928, two large males of this species were captured at Guadalupe and placed in the Zoological Garden at San Diego, where they died some months later.

A number of fur seals had been observed at the island in May, 1929. Our party found none in September, a date certainly well past the breeding season. Reports have been received from fishermen that fur seals were observed in the vicinity of the Santa Barbara Islands, California, during the summer. The fur seals supposed to be breeding at Guadalupe Island, may have moved northward temporarily.

Another search will be made at Guadalupe next May, with a view to securing information respecting the reappearance of this seal. One of the males taken from Guadalupe to the San Diego Zoological Gardens is now in the possession of the writer, who has prepared for early publication a detailed description of its skin and skeleton. The two males referred to above, are as yet the only museum specimens known to naturalists. The original description was based on a weather-worn skull.

The other male, when mounted, will be presented by the San Diego Zoological Society to the National Museum in the City of Mexico. The Mexican Government has granted to that Society, permission to capture two more of these seals, should a herd be found at Guadalupe Island.

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Vol. XXXIII, No. 2 March-April, 1930

BULLETIN
NEW YORK ZOOLOGICAL SOCIETY

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APR 29 1930
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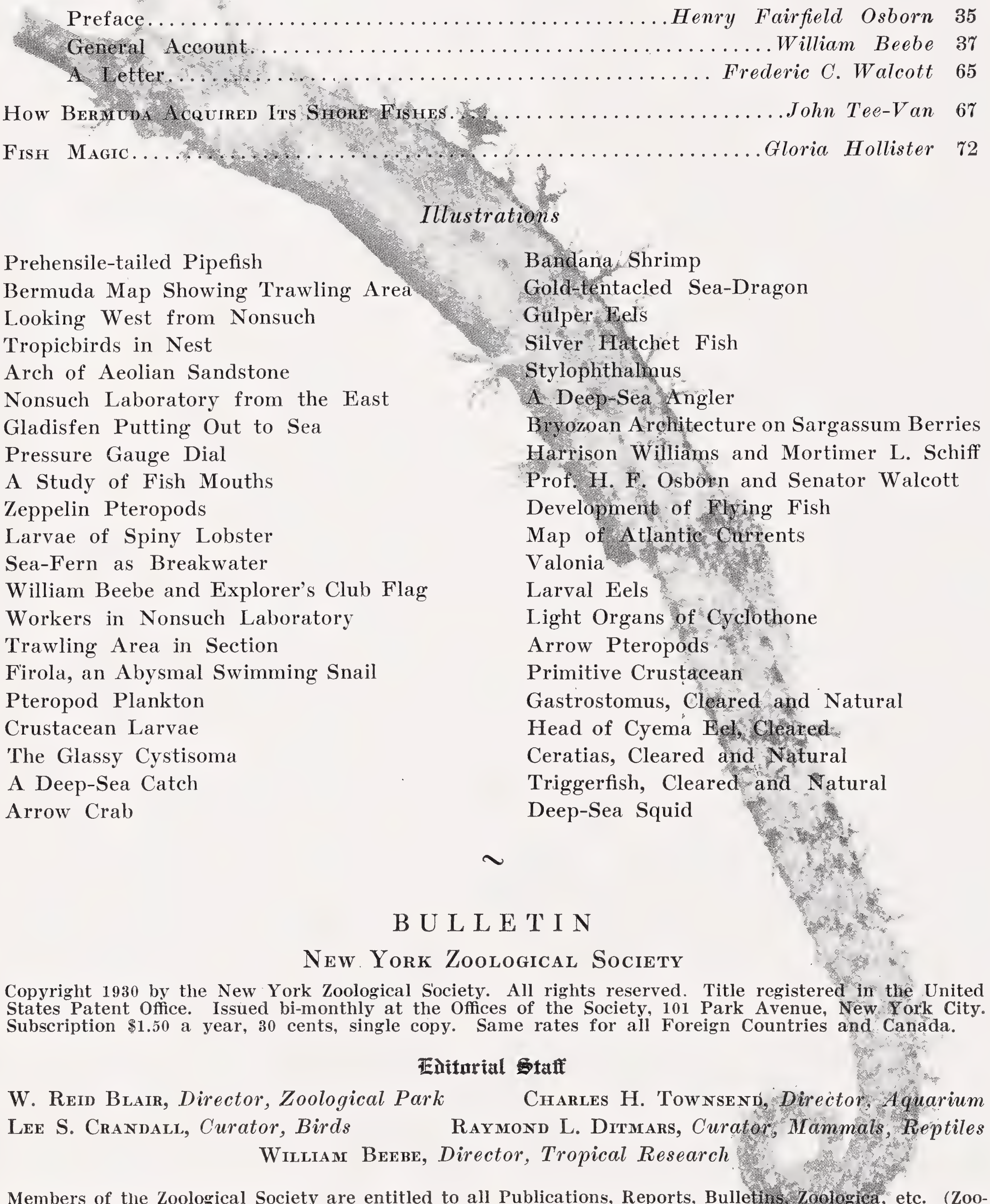

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Deep-Sea Squid

BULLETIN

NEW YORK ZOOLOGICAL SOCIETY

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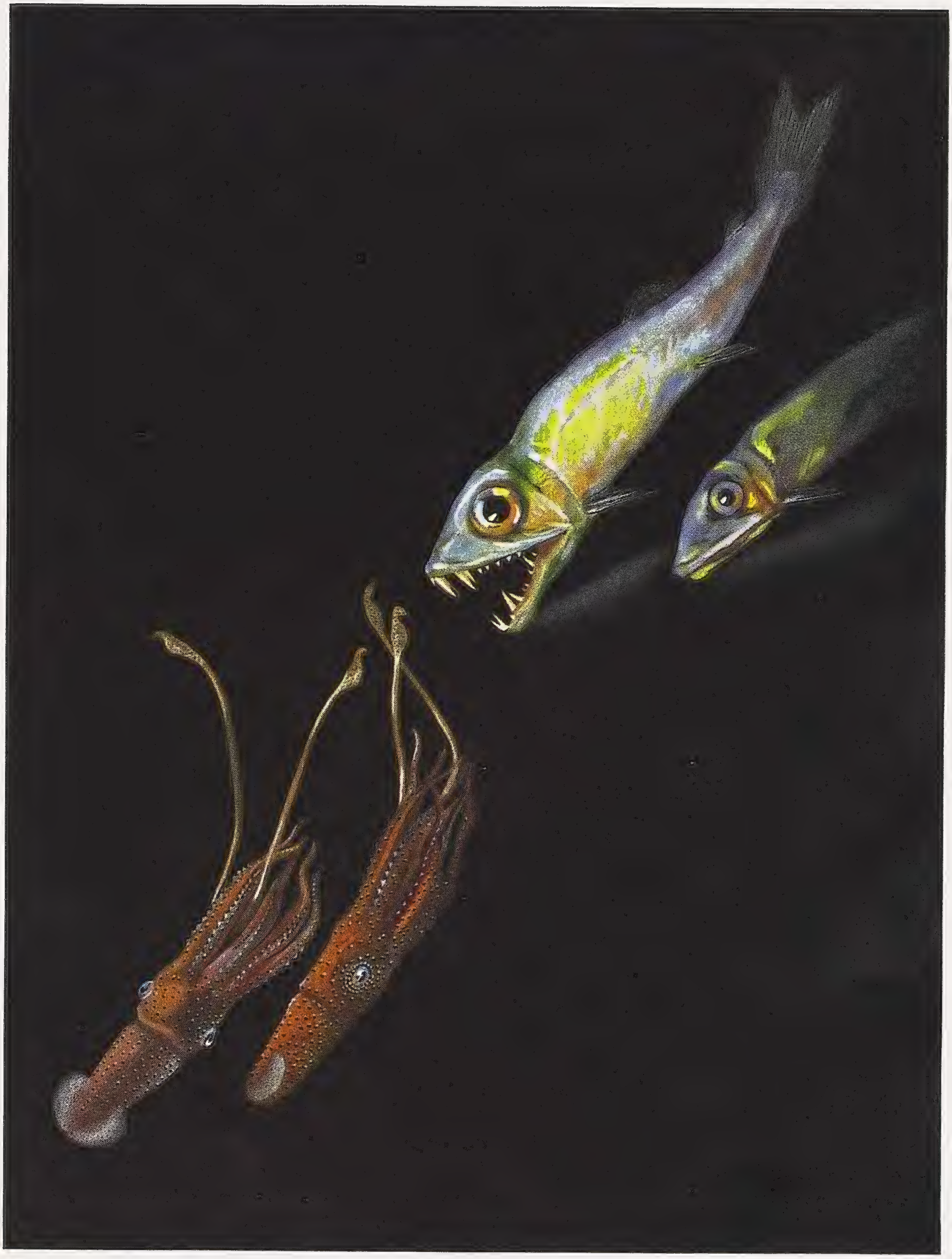

The deep-sea fish, *Omosudis lowii,* pursuing its prey—luminescent scarlet squids, at a depth of 900 fathoms. Painting by Else Bostelmann.

BULLETIN
NEW YORK ZOOLOGICAL SOCIETY

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The Bermuda Oceanographic Expedition

Twelfth Expedition of the Department of Tropical Research of the New York Zoological Society

William Beebe, *Director*

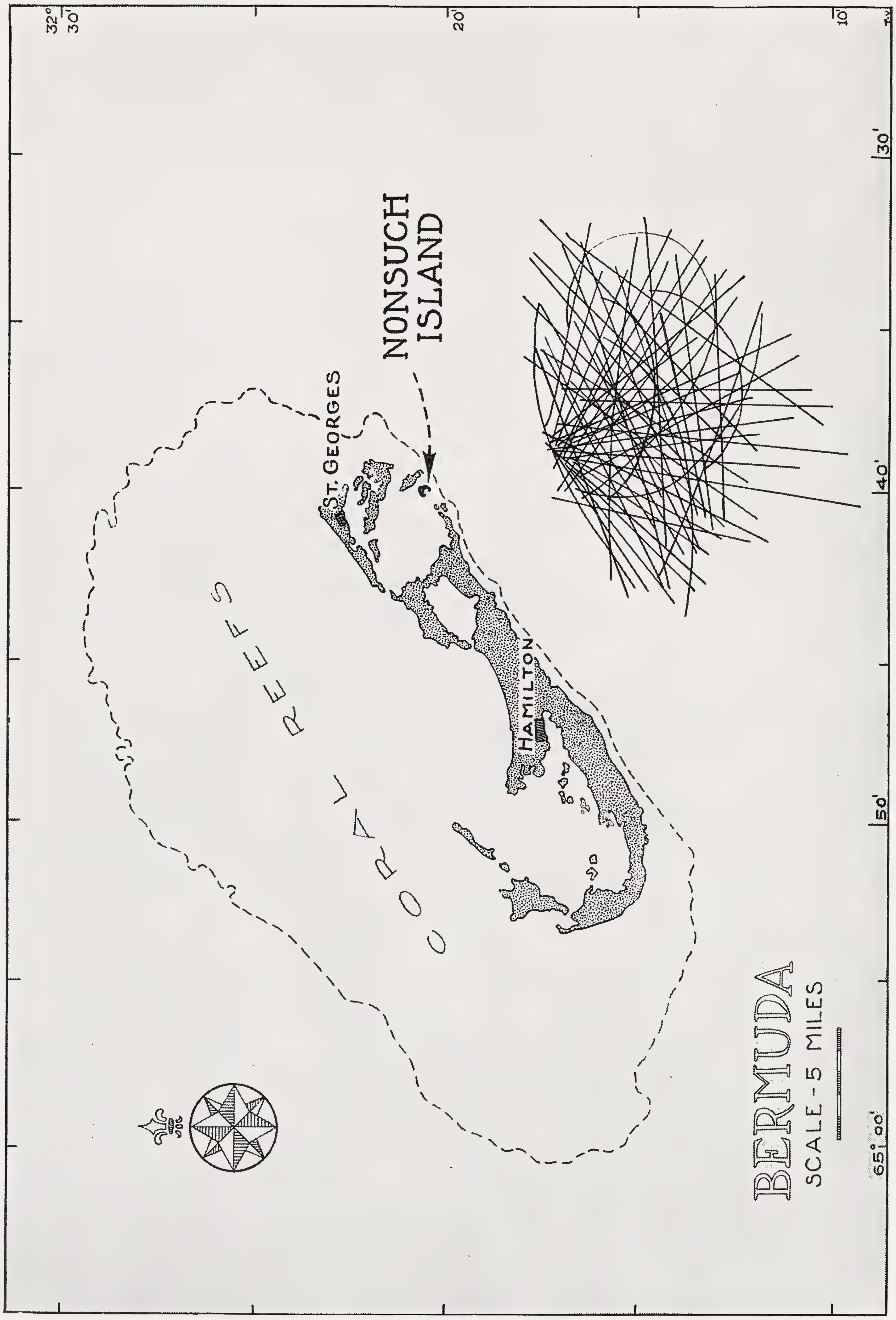
Photographs by Robert Whitelaw.

PREFACE

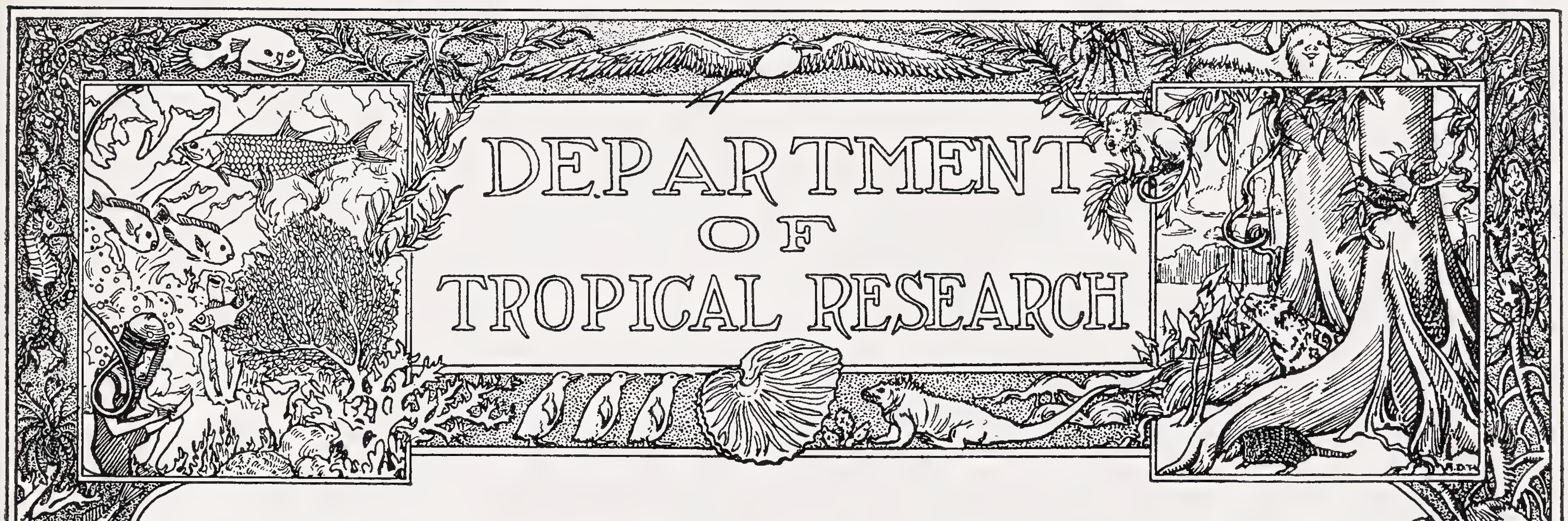
Henry Fairfield Osborn,
Honorary President, New York Zoological Society.

To William Beebe's splendid report I preface the following: I visited Nonsuch Island during the month of April, 1929, in order to see for myself the actual work of this Oceanographic Station, the opportunities afforded by this special point on the Atlantic, the personnel of the laboratory, the equipment, and especially the splendid quarters provided through the liberality of the Government of the Bermuda Islands. I was immediately convinced of the rare combination of supreme opportunity for oceanographic research and of unsurpassed facilities. On my return to New York I immediately wrote to two of our trustees, Messrs. Mortimer Schiff and Harrison Williams strongly recommending the work of the Station and endorsing their generous contributions. Through these and other donations Director Beebe and his staff were enabled to continue work through seven months of the season of 1929. Furthermore they are assured by the Bermuda Government that the same priceless opportunities will be offered another year. Toward this really great oceanographic work, unsurpassed of its kind in intensity and promise, all the members of the Zoological Society are invited to give their endorsement and to back the expedition for the coming season of 1930.

The icy-cold depths of the ocean off Bermuda are quite as wonderful in the richness of present life as the super-heated arid plains of the Gobi Desert are in the past life of the world. We may well be proud of the determination of two American leaders of modern exploration: William Beebe in the icy ocean depths; Roy Chapman Andrews in the torrid deserts.



Map of Bermuda showing the island of Nonsuch and the location of the daily, deep-sea trawls made five miles off shore. Drawing by John Tee-Van.



Bermuda Oceanographic Expedition

The Twelfth Expedition of the Department of Tropical Research

It is seldom wise to prophesy anything of a scientific expedition, but if the projected schedule of this Bermuda trip which I ventured to outline in a Zoological Society Bulletin a year ago were changed from future to past tense it would now be justified as fact.

Four years back, from the bridge of the *Arcturus,* I saw the patch of floating mist which is Bermuda eight miles away. At this period, nearing the end of our six months cruise, I was vividly aware of the great cost of oceanographic expeditions and of the surpassing generosity of Harrison Williams which had made possible the Arcturus adventure. No wonder the abysmal deeps of ocean keep their secrets so closely when the cost of every fish brought up suggests weighing scales marked, not in ounces but carats! It was about that time that the thought of a shore-laboratory and a sea-going tug first occurred to me.

The primary link in this scheme was carried out at once and I made four Arcturus Stations near Bermuda, one within ten miles of the shore. The series of nets which we sent down to a mile depth brought up an abundant harvest of strange creatures. This made me certain that close to Bermuda there was an unfailing supply of deep-sea life available for study.

Two years ago in New York harbor, through the generosity of Major Vivian Drake, I was able to prove the second proposition, by making successful hauls a mile deep with my small Arcturus winch and wire on the deck of a tug.[1]

Finally during a recent visit to Bermuda, when on a picnic on one of the outer islands with His Excellency the Governor Sir Louis Bols and the Honorable F. G. Gosling, I was offered the use of the island if I would return and carry on scientific work. This generous offer was ratified by Parliament and in the name of the Zoological Society I accepted, and my hopes on the bridge of the *Arcturus* crystallized into possibility. At the annual meeting of the board of managers of the Zoological Society Mr. Mortimer Schiff and later Mr. Harrison Williams guaranteed the financing of the idea, and the Twelfth Expedition of the Department of Tropical Research became a certainty.

On past expeditions I have successfully carried out certain definite aims in regard to particular zones of life. In the jungles of British Guiana I concentrated on the host of tiny organisms living in a square yard of tropical forest floor;[2] the bird-life of a solitary tree;[3] the census of a single walk;[4] and the fauna of a quarter of a square mile of jungle;[5] on the *Noma* and the *Arcturus* I had been able to study in detail and at leisure the life of a single group of islands,[6] and the amazing mass of living beings in a current rip in mid-ocean.[7] In Haiti I worked for half a year on the shore fish within a three-mile radius of my schooner.[8] Now, at

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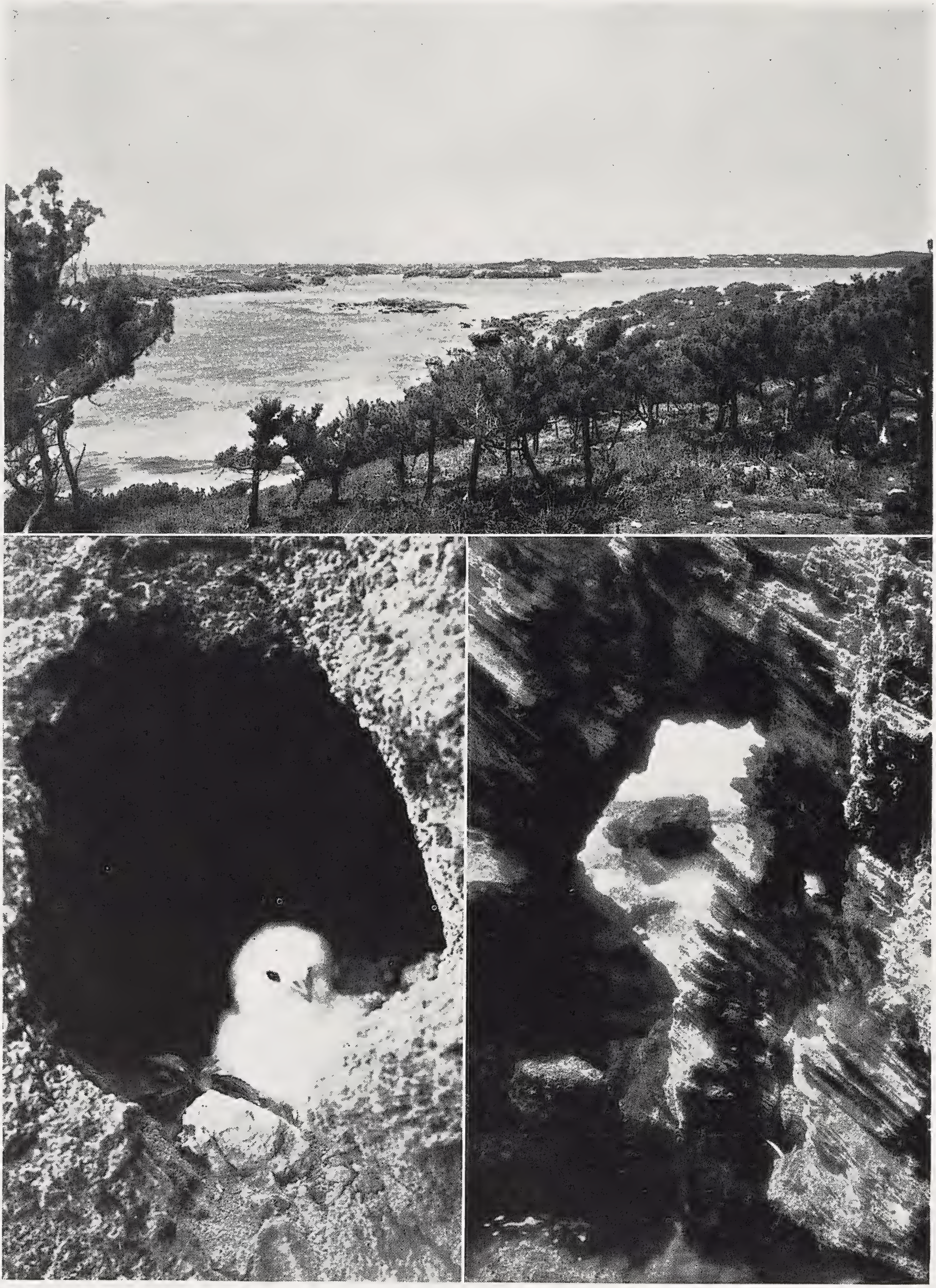
[1] Zoological Society Bulletin, Vol. XXXII, No. 2, p. 69.
[2] Jungle Peace, p. 239.
[3] Jungle Days, p. 137.
[4] Zool. Soc. Bull., Vol. XXIV, No. 6, p. 139.
[5] Zoologica, Vol. VI, No. 1.
[6] Galapagos: World's End.
[7] The Arcturus Adventure, p. 41.
[8] Zoologica, Vol. X, No. 1.



Looking West toward Castle Island and the Mid-Ocean Club from Nonsuch.
Young Tropicbird in its rocky nest.
A wave-worn arch of aeolian sandstone and a Tropicbird's nest.

Nonsuch Laboratories from the east, looking across Castle Roads toward Tuckerstown.

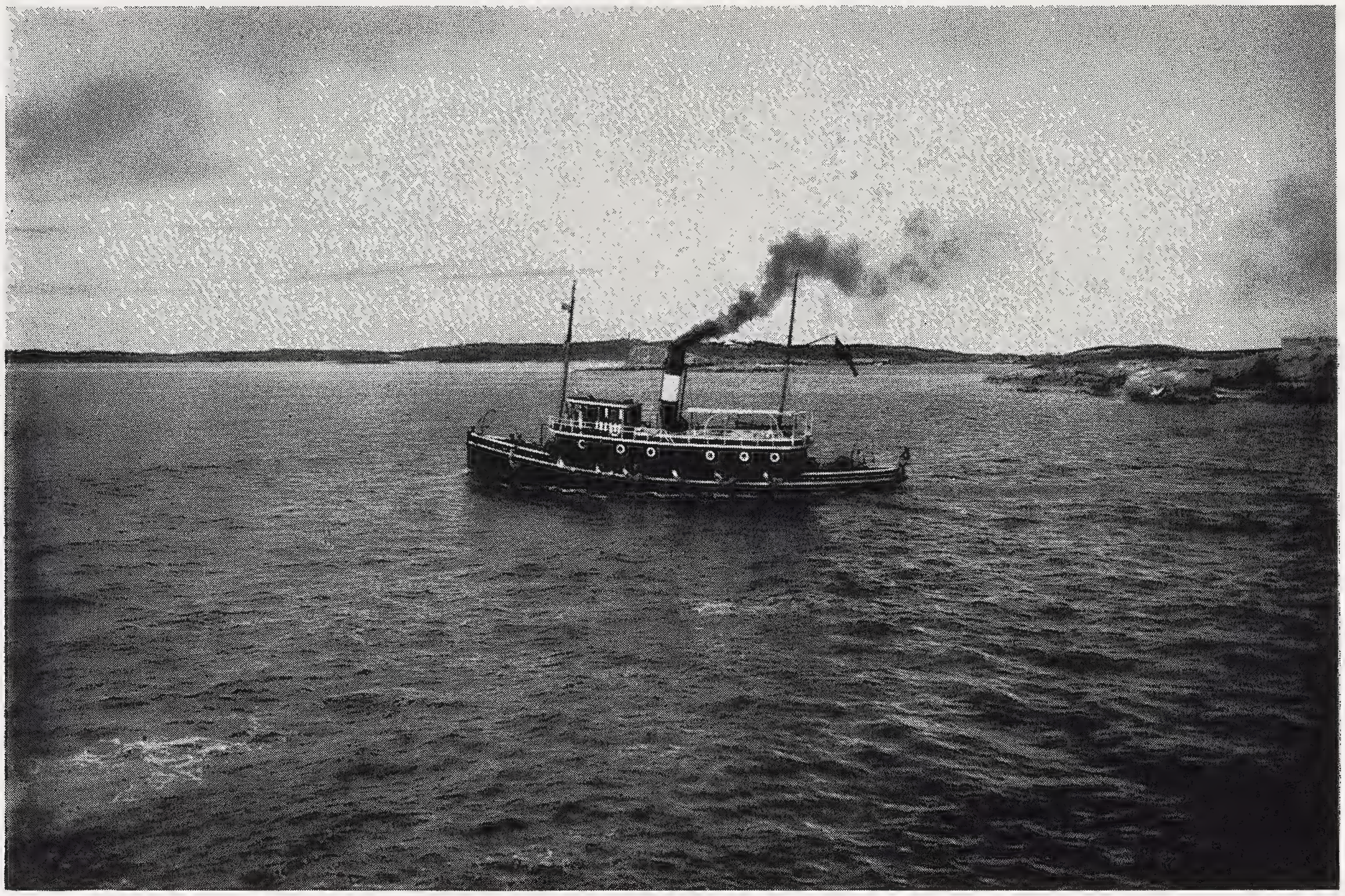
last, I could do what for years had been my greatest desire, to draw hundreds of nets, day after day, for months, through a circumscribed area of deep sea.

The Arcturus Expedition had been a signal success but in general I had slavishly followed the methods and routine of all my oceanographic predecessors, namely to let down a series of nets, draw them slowly through the water for a few hours, pull them up, then steam several hundred miles away and repeat the process. The plotted routes of most large expeditions since the time of the *Challenger,* look exactly alike—a string of station beads strung across the ocean. Such pioneer work is necessary and the results are of lasting value for definite knowledge is gained as to new species, vertical distribution, etc. But the hauls are isolated, unrelated, independent; there is no intimate correlation between them. On this Bermuda Expedition I intended to accomplish in the deep sea what I had in a quarter of a square mile of jungle, to correlate my hauls, to make every individual fish mean something besides the mere fact of its name and capture.

When once more I was fortunate enough to win the favor of the god of Expeditions—Roon, doubtless, the god of Going—all details fell smoothly into place. If I had had the choice of any of the 365 islands which make up Bermuda, I would still have chosen Nonsuch, the very one which had been turned over to me, the chief reason for this being that a mile depth of ocean was closer to shore at this point than anywhere else.

The cost of this whole year's work compared with that of the ordinary oceanographic expedition was small out of all proportion to the splendid hauls we made every day. If we consider all the deep-sea fish collected, (a large percentage new to science, all weird, and all impossible of capture without complete oceanographic equipment) we find that their total cost, based on that of the whole expedition, was less than half a cent each.

Soon after we had taken possession, I realized what a remarkable opportunity this was and how precious was its realization to the full. There was impressed upon me, too, the magnitude of trying to complete even a superficial study of



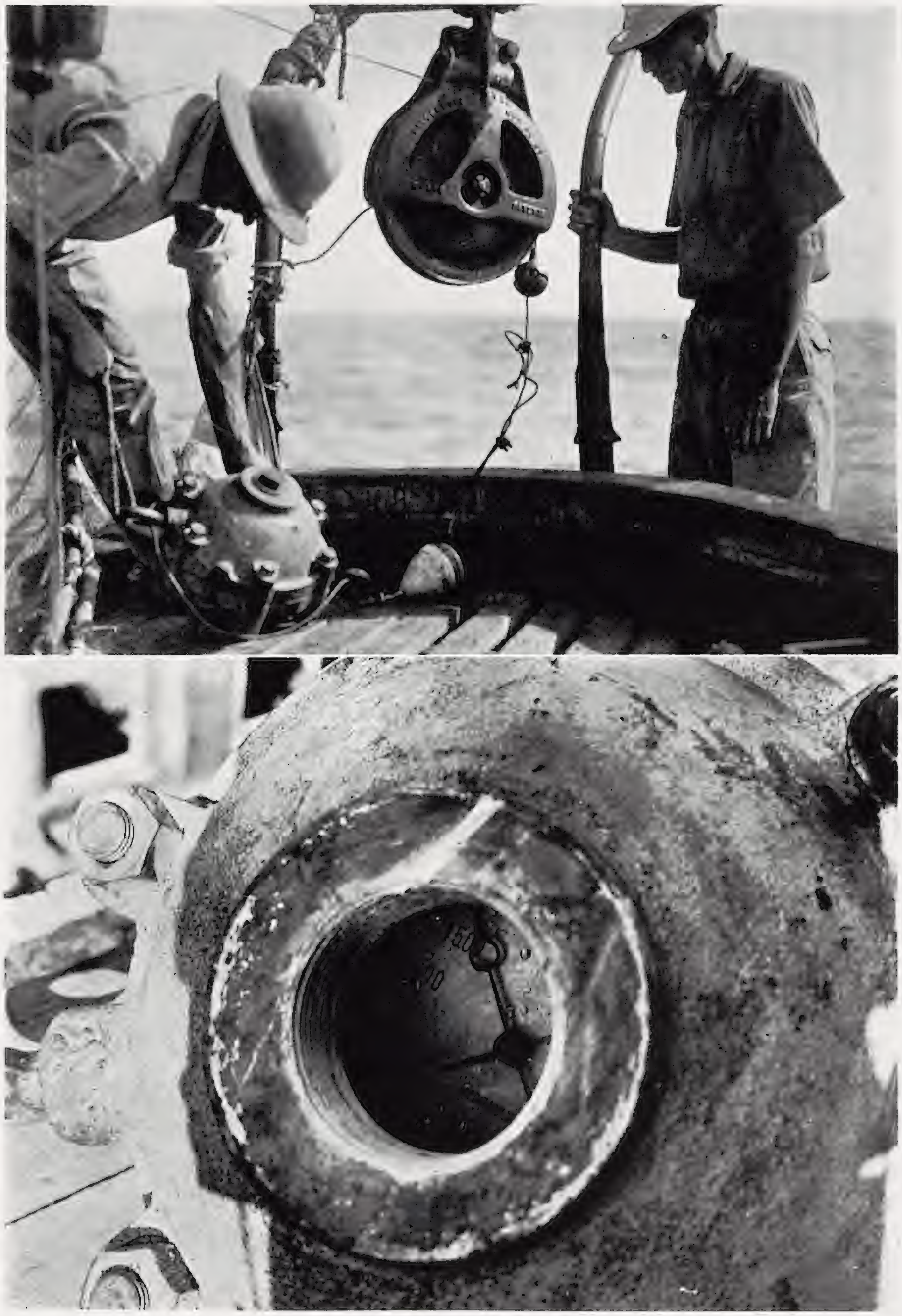
The Zoological Society's tug *Gladisfen* passing out to sea for a day's trawling. The *Arcturus* winch can be seen on the aft deck.

the shore and of the deep-sea fish of this area in a single season. Almost simultaneously, the island was offered me for another year and tentatively I accepted. So instead of pushing ourselves to the extreme physical and mental limit, I laid out a more deliberate, philosophic campaign, with the hope of two seasons' research in this ideal environment with its superlative opportunities.

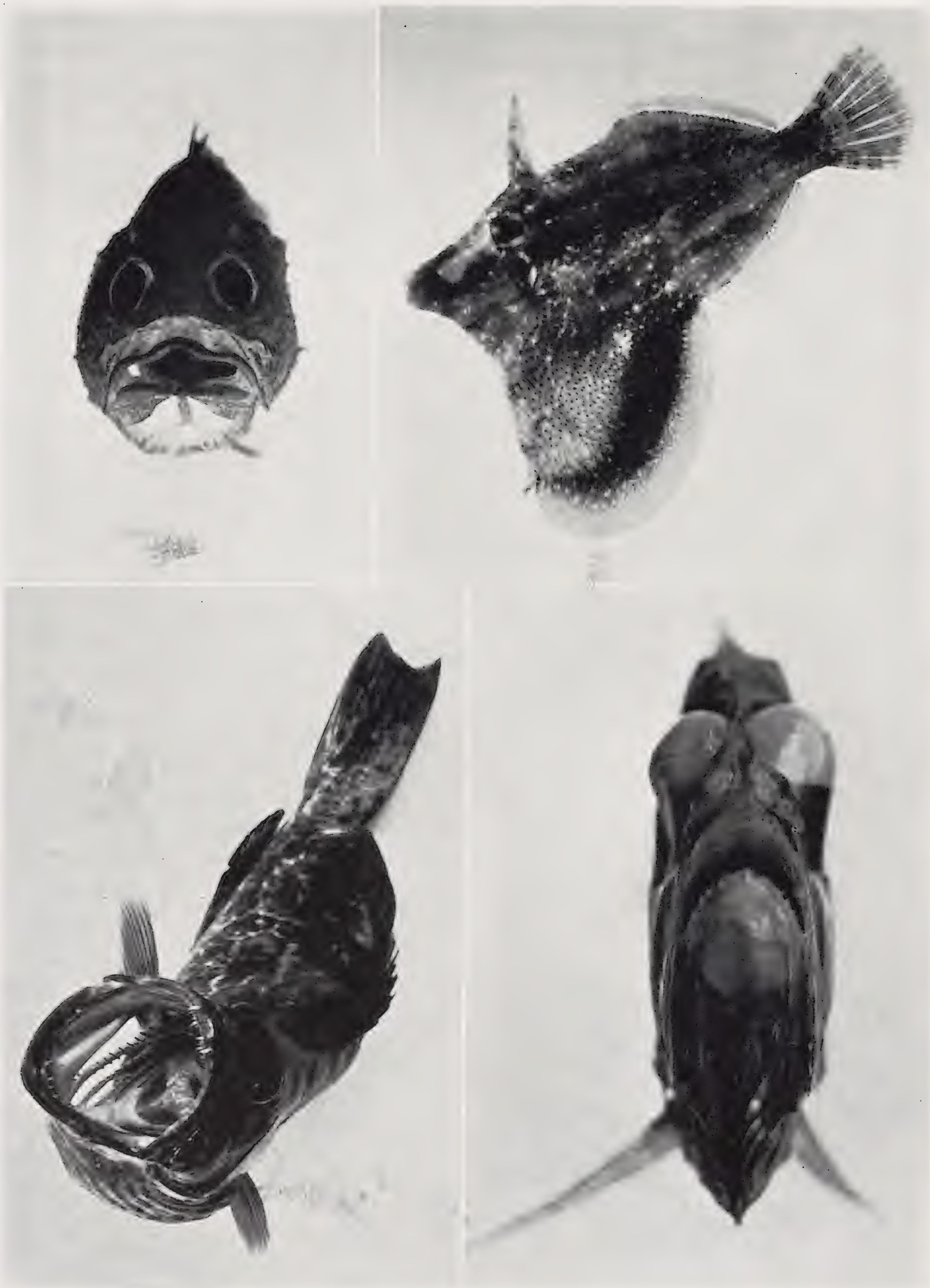
Many Bermudians agree with me that Nonsuch is the most beautiful of all their compact, little archipelago-islands. It consists of twenty-five acres, rising steeply up sixty to seventy feet of jagged cliffs on the north, and sloping gently southward,—its core of aeolian sandstone covered with sturdy, wind-blown cedars and aromatic sagebush. During the year it is successively pink with oleanders, rose-red with hibiscus and brilliant with goldenrod. Every morning there arises above the pounding of the surf, a chorus of the soft murmurs of bluebirds, the loud *Q! Q!* of cardinals, and the sweet warbling of white-eyed vireos; catbirds call, ground doves murmur to one another, and long-tailed tropic birds wheel in dozens about their nests in the sandstone caves.

At night we have in the distance the steady gleam of St. David's light, until, through the dark foliage of the cedars the sun rises over the white sand of two beaches. To the north there stretches the three mile circle of Castle Harbor, a mosaic of emerald shallows and lavender coral reefs, while on its farther shore we can just see the quaint, medieval town of St. Georges. Swinging around to the west we have a striking contrast of the new and the old—the Mid-ocean Clubhouse in the distance, while close at hand three old British Forts, built about 1600, cut the horizon with ruins as picturesque as any in the Old World. These once guarded Castle Roads which is still our route to the sea. Due south we have the open ocean forever hurling foam over Gurnet's Head, the force of its waste of waters backed by the prevailing winds, the shifting tides and the steady push of the Gulf Stream.

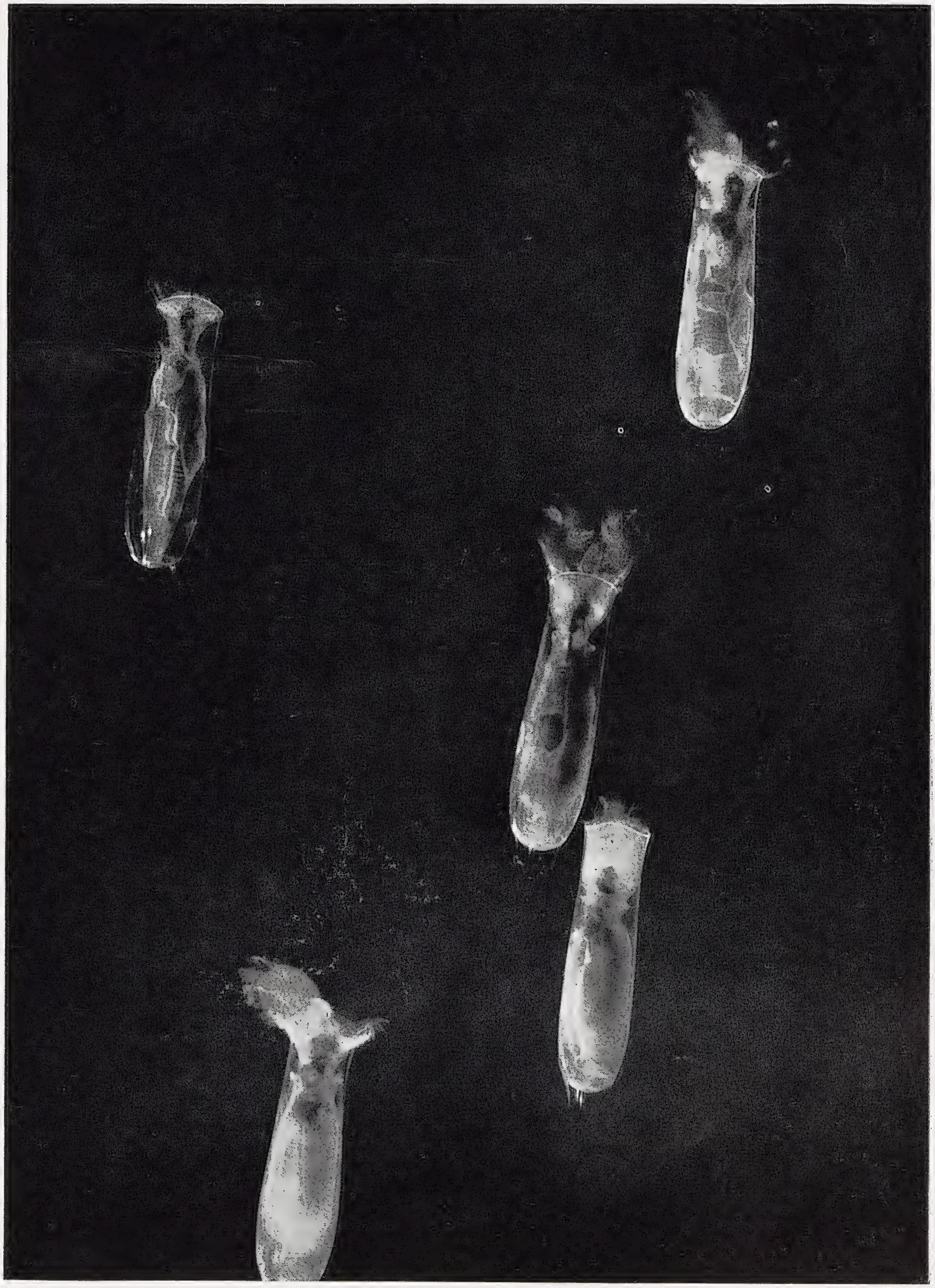
On the summit of the island are the two large buildings, which together with a cluster of



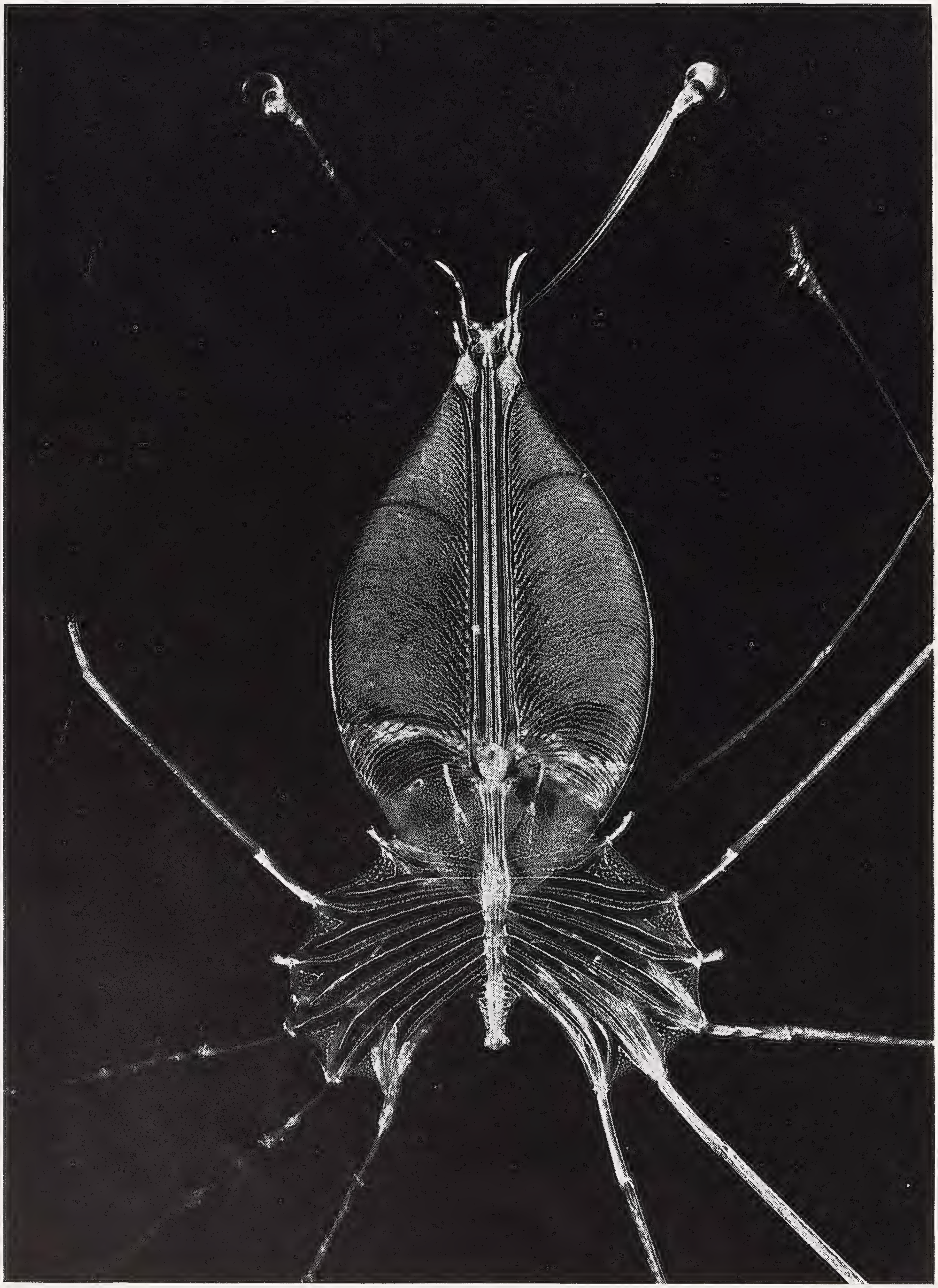
Deep-sea pressure gauge invented and presented by Mr. L. R. Smith. *Upper:* Showing method of lowering the gauge on the end of the cable. *Lower:* Photograph of the dial on the instant of opening, showing the pressure of 1600 pounds recorded at a depth of more than half a mile.



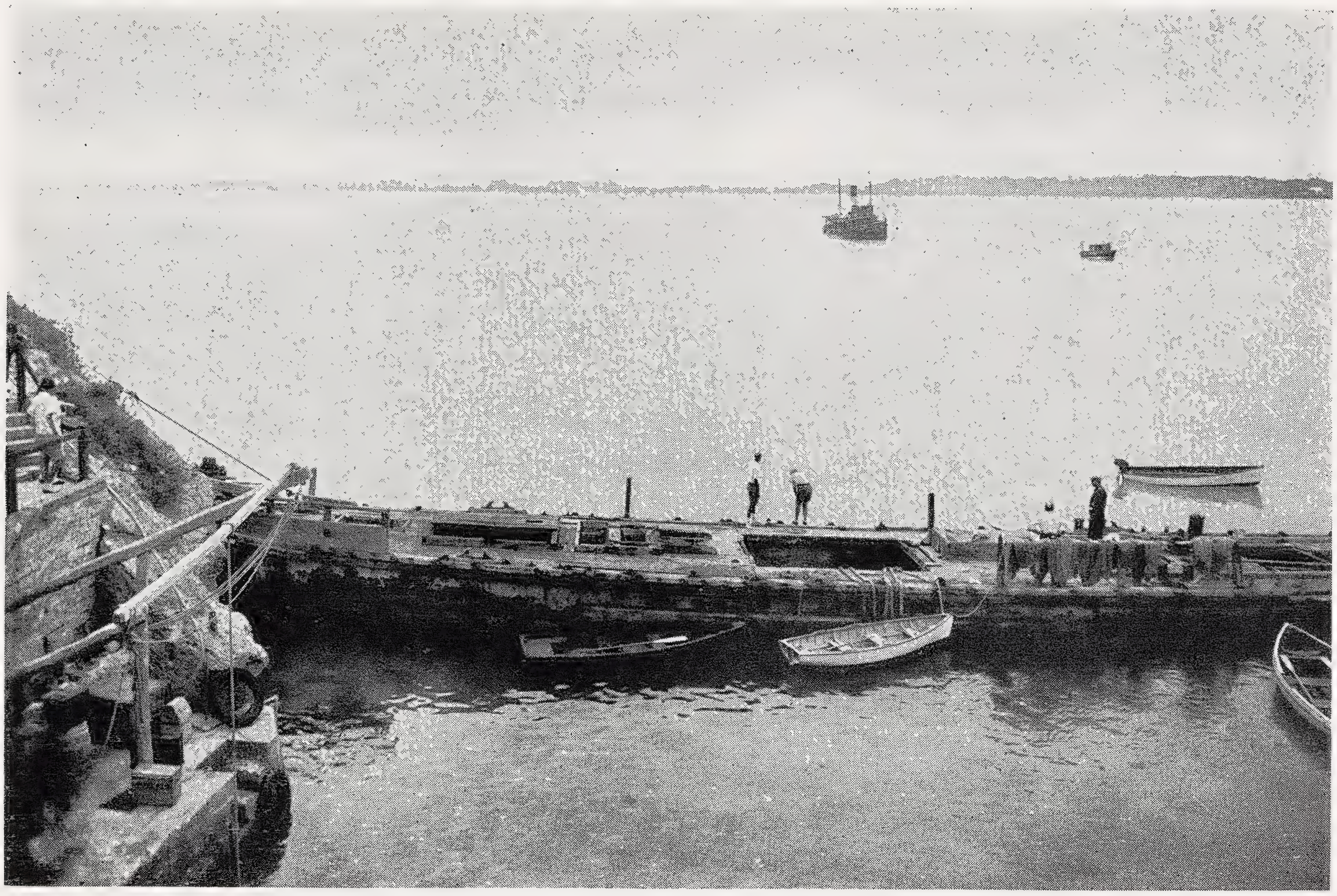
A Study in Fish Mouths. A rare soldier-fish (*Plectrypops*), Trigger-fish (*Monacanthus*), Rock-fish (*Mycteroperca*), and Silver Hatchet-fish (*Argyropelecus*).



Zeppelin Swimming Snails—Pteropods. *Cuvierina columnella.*



Transparent larva, called *Phyllosoma,* of the Spiny Lobster, *Panulirus:* thin as tissue paper, transparent as glass.



Wreck of the *Sea-fern,* which was raised in St. George's Harbor, transported across the bay and resunk at Nonsuch wharf for a breakwater. This done by kindness of the Bermuda Legislature and Mr. Meyer.

smaller ones have been given to us by the British Government for use as laboratory and home. They are gleaming white, part and parcel of the island sandstone quarried near by; their ceilings are high, the plumbing and the kitchens in order, the large rooms cool and pleasant. It might all have been built to order for our purposes.

For the laboratory proper we had only to enclose two large porches with celloglass and window frames. I chose those facing north, both for better light and to be on the opposite side from the utterly lovely southern outlook. It would have required constant effort to cease looking out at the ever-changing beauty of ocean and shore, sky and cedar-clad slopes.

One small outbuilding houses our electric plant, the same motor which did such yeoman service on our schooner in Haiti. Here it is reincarnated and for seven months never coughs or hesitates, but provides a steady current for sixty-odd electric light bulbs, oxygen pumps for the aquarium and a frigidaire. Major Drake and Mr. Browne purchased and erected for us a gasoline pump, which lifts three hundred gallons of sea water an hour from sea-level at our wharf to the summit of Nonsuch, supplying all the aquariums.

The two largest rooms are used as dormitories, although some of the members of the staff choose to live in tents which they erect on various picturesque parts of the island. Our Arcturus glass-bottomed boat is still useful and we have two additional boats with outboard motors. Our fleet is completed by a thirty-five foot launch for daily communication with St. Georges and the outer world.

The landing place is at mid-island on the north side, and at first was most precarious, a storm of unusual strength having power to isolate us for several days and to necessitate the raising of all our boats on davits or hauling them up on the beach. A casual wish of mine was translated by a Bermuda friend into an official request, and within two weeks the Bermuda Parliament voted to raise a large sunken

William Beebe attaching the Explorers Club flag to a large net, just before it descended to a mile and a half.

steamer in St. George's Harbor, tow her to Nonsuch and resink her close and at right angles to our wharf. This was done and by the superlative kindness of our friends we now have a perfect breakwater and sheltered cove, safe in all weathers. Moreover the inside of the hulk affords five large natural wells, in which we keep living fish, those intended for food as well as others of scientific worth.

To this island station, the most beautiful I ever established, we came on March 15, 1929, and in less than three weeks the machinery of collecting and research was running smoothly. I had a staff of eight, trained and enthusiastic, needing to be held back from overdoing rather than urged on.

I chartered a powerful sea-going tug, the *Gladisfen,* put our electric sounding apparatus on deck and the Arcturus winch with three miles of quarter-inch steel wire.

Our work on the fish of Bermuda may be divided, like Gaul, into three parts, although these merge more or less insensibly into one another;—first the shallow water fish, second those of the mid-depths, and finally the fish of the open ocean and its mysterious deeps.

In this Bulletin I can speak only very generally of our results for there has not been time since our return for detailed study of the collections.

Shallow-water Shore Fish.—Every tide-pool and coral reef had its hosts of fish, varying from the tiniest of crevice-living gobies to great sharks which nose their way in on every tide. Our work in this department of fish life was similar to what we did with West Indian fish in Haiti.[9] Mr. Tee-Van interested himself in the major work of identification and color description. As in Haiti we found an abundance of fish life close about our station and we hardly ever went three miles away from Nonsuch. During the time of our stay we collected and studied two hundred and five species, which is considerably more than two-thirds of all the known shore fish of Bermuda. I hired a trained fisherman, a St. David's Islander and his son, who

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[9] Zool. Soc. Bull., Vol. XXX, No. 5 and Zoologica, Vol X, No. 1.

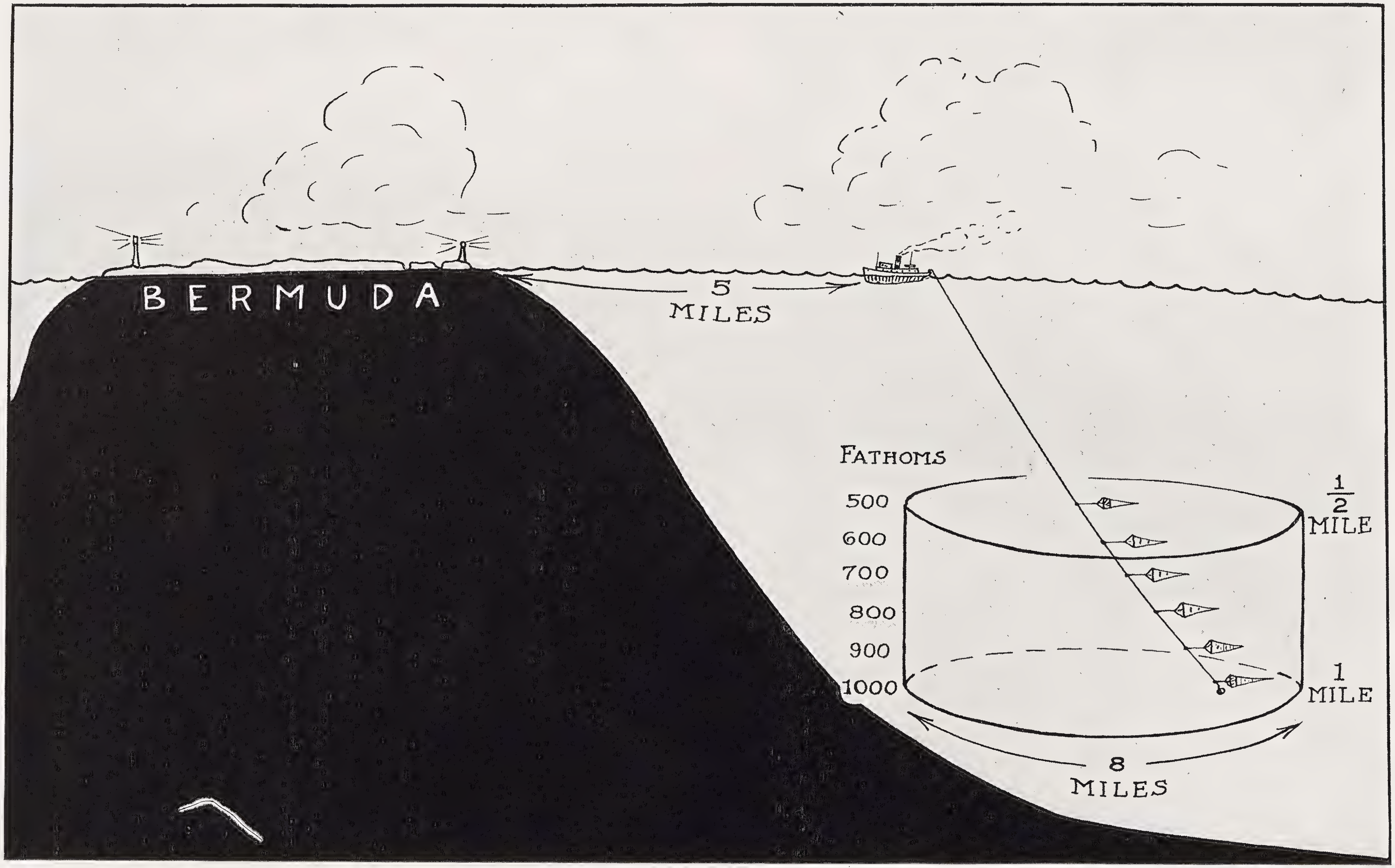
Nonsuch Laboratory showing Dr. and Mrs. Fish, John Tee-Van, William Beebe and Gloria Hollister.

brought us all their catches both for food and specimens, and taught us much of local fish lore. Mr. Mowbray, Director of the Aquarium, was most generous with his thorough knowledge of the fish life of these waters, and helped us in many ways.

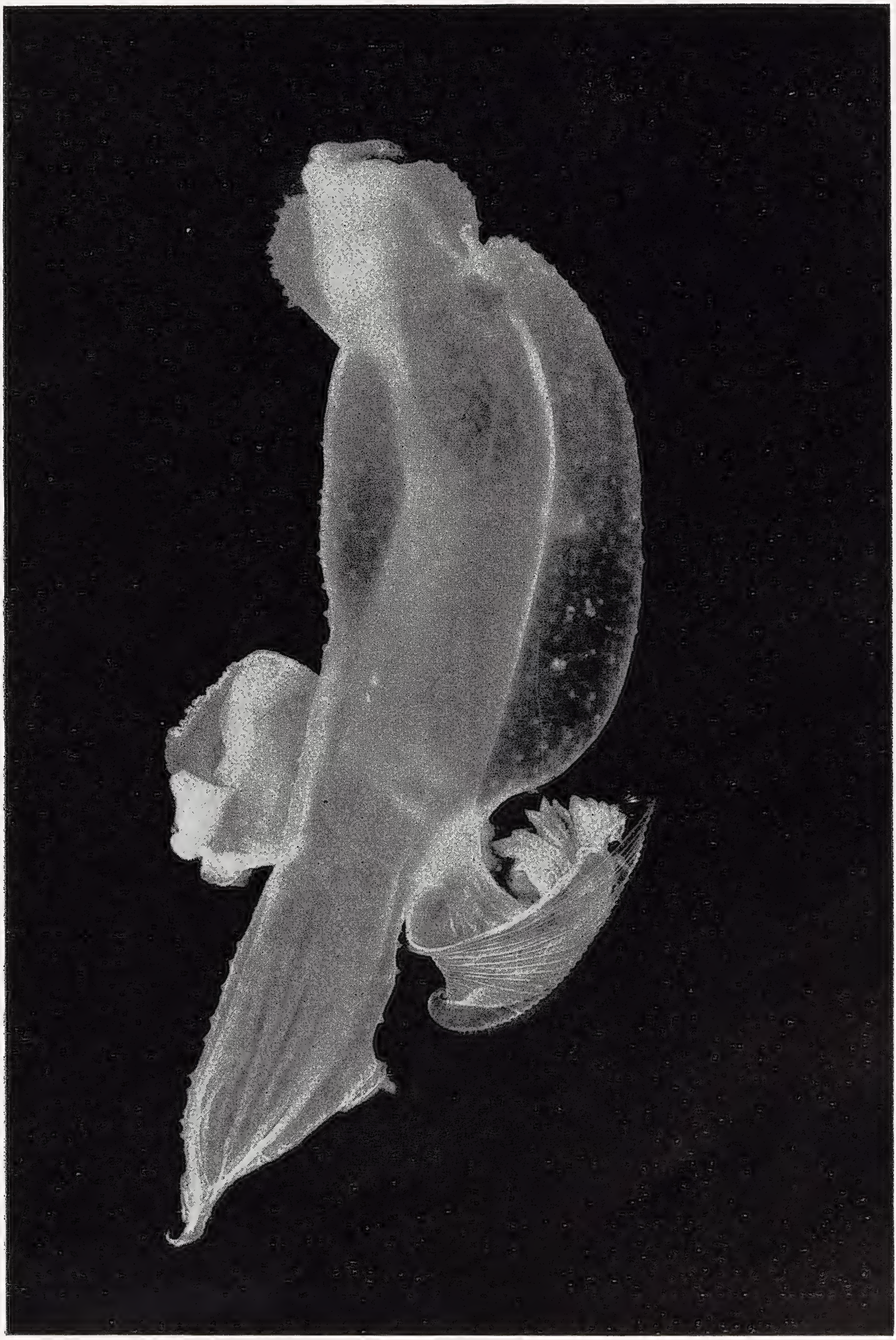
We sought to enter into the private lives of these fish, to learn of their times and seasons, the reasons for their change of colors, their breeding habits, food and enemies. When it was calm enough to use the diving helmet we found it, as always, of inestimable value. Half way out to the rugged cluster of rocks known as Gurnet's Head was a particularly beautiful coral reef, reaching to within a few feet of the surface. This, I had discovered the year before and named "Almost Island," and here we dived when we could, walking about its sandy paths, pulling ourselves up its sheer coral walls, or creeping beneath overhanging arches, through living portieres of waving sea-plumes.

At the end of this year's work I realized as never before the sharp distinctions between the life habits of various groups of fish. Looking down through the water from a glass-bottomed boat is like peering at the land through a fog from a low-flying zeppelin. From such a viewpoint there would be little contrast between the habits of robins, woodpeckers, hawks, snipe and ducks. The same is true of fish, and only when at last we identify ourselves with their coral haunts, does the orderliness of this great submarine world begin to be clear and understandable.

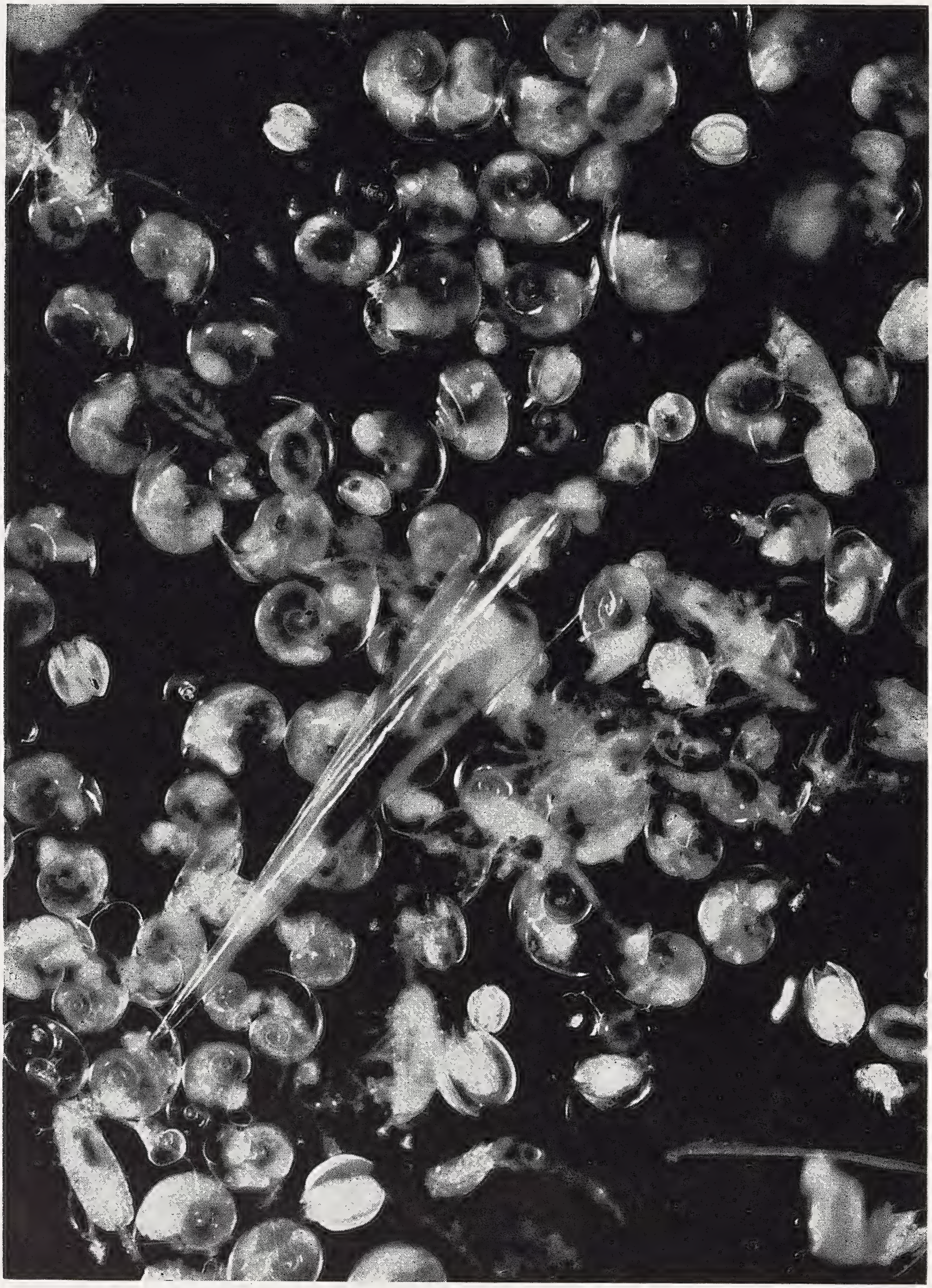
Hidden in the sand are the all but blind worm-eels, and Amphioxus,—that nearest living thing to the ancestor of all fishes. On the sandy bottom live flounders, nurse sharks and lizard fish, while in tide-pools gobies, blennies and strange dwarf brotulids make their home. Butterfly-fish and demoiselles keep close to their nests among the rocks, and at night morays and squirrel-fish come forth from the crevices and holes in the corals. In midwater the fierce mackerels and jacks hunt in schools, while near the surface vast numbers of fry live lives which seem one long attempt at escape from death. We learn to know the fifty-odd families of the



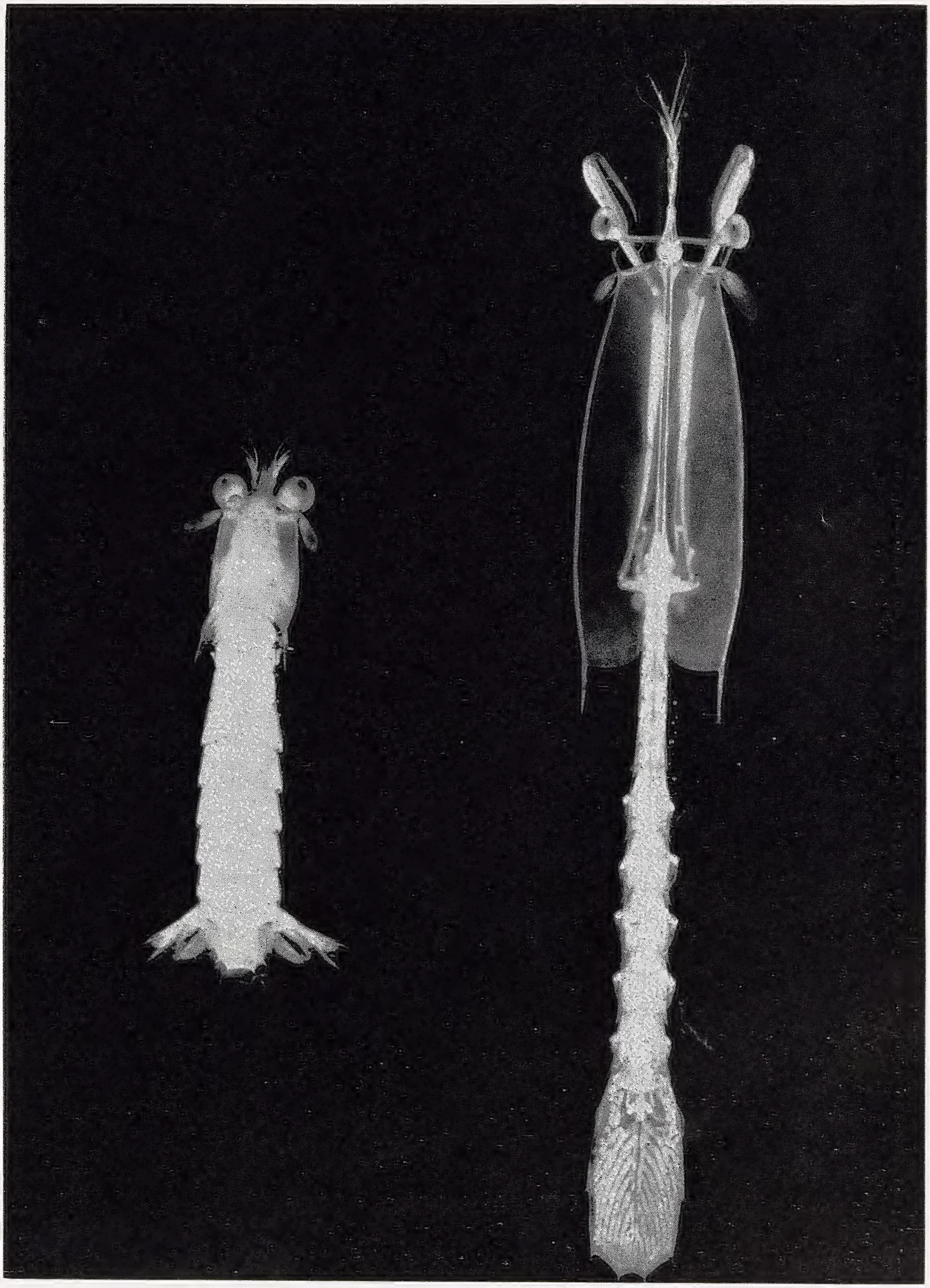
Diagrammatic view of the deep sea near Nonsuch, showing the tug drawing six nets through the area of operations—an imaginary, but fixed, submarine cylinder, 5 miles off shore, 8 miles in diameter, and one-half to one mile beneath the surface. Sights from the two light houses enable the location of each haul, in degrees and minutes, to be exactly calculated. Drawing by John Tee-Van.



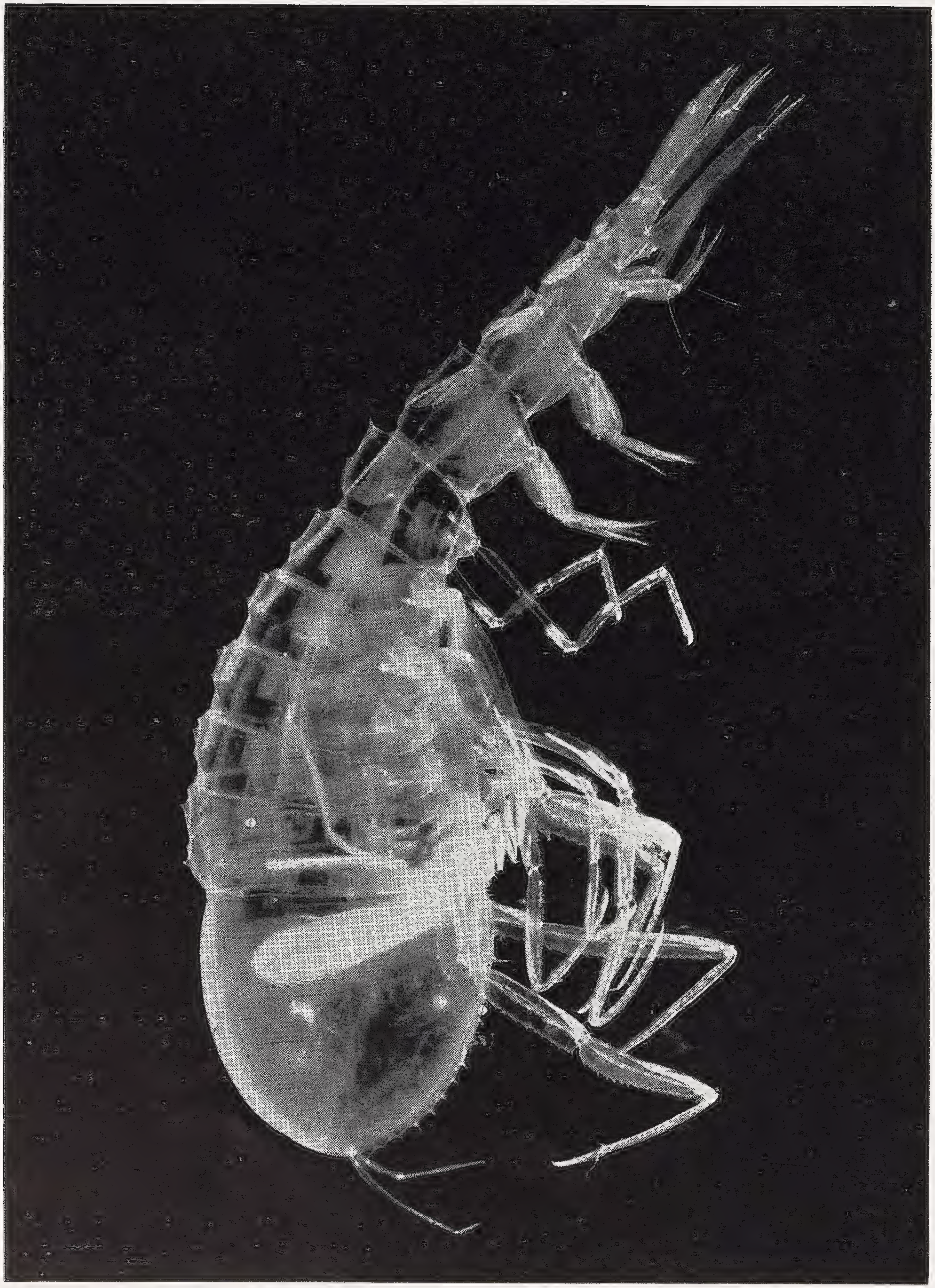
Firola, a very beautiful, luminous, deep-sea swimming snail, with a delicate tissue shell shaped like a liberty cap.



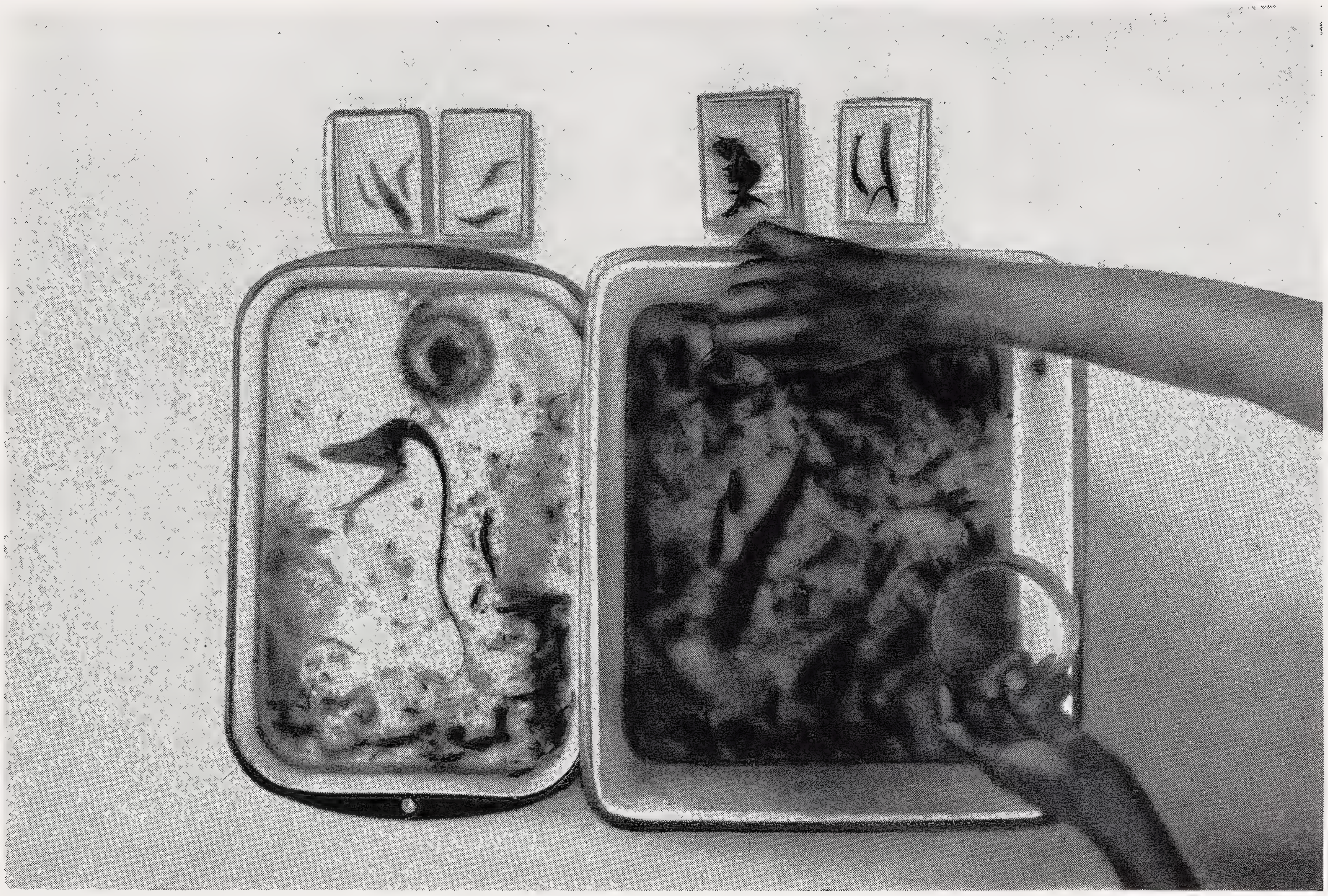
Minute wandering forms of life known as Plankton, found floating at great depths in mid-ocean.



"Split-finger" or Stomatopod, full grown one and a transparent larva.



A very beautiful transparent crustacean, *Cystisoma neptunus.*

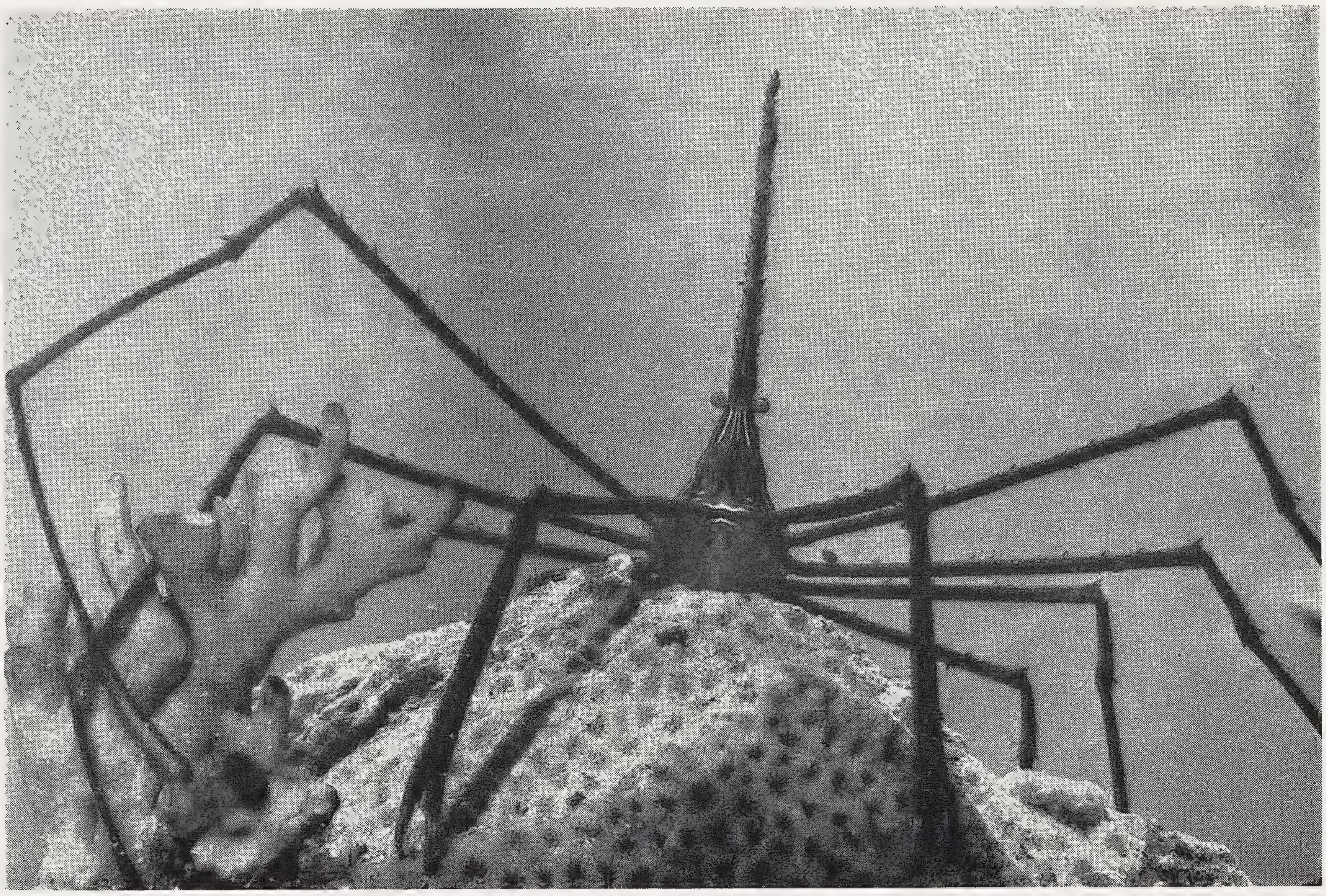


Two netfuls of deep-sea life from 900 and 1000 fathoms, much of it still alive, in the process of being sorted for study.

shallow water fish in a way new to us, making them less mere names, and more fellow beings on the planet with us and with other creatures of the dry land. In this way their forms, patterns, colors, fins, mouths, come to have new and clearer meanings for us.

Our aquariums proved of utmost value. In them we hatched the eggs of fish, watched the feeding habits of others, noted the color change between day and night, calm and fright, and observed strange sleeping postures. If we had seven years instead of seven months this one phase would not become exhausted. In these few confined quarts of ocean, embryo flying fish wriggled about in their eggs and finally burst forth into freedom; here flounders opened their mouths and drew living fish into them by sheer undiscernible magic; here three species of wrasse became one by shift of color and pattern; here the soap-fish justified its name by embedding itself in a veritable mountain of firm bubbles.

Fish of the Mid-Depths.—The Mid-water fishing was real pioneer exploration. From twenty to one hundred fathoms off shore the bottom is a jungle of coral rocks too deep for the helmet, too rough for the nets or dredges. It is a region as unknown as the summit of Everest. William Merriam and later Arthur Tucker played dominant roles in this field. Ingenious traps and buoys were devised; currents and winds studied, the great telescope was trained for hours on the distant floating flags. Then after days of effort, the wire or cord line was drawn up until it became taut and finally, in spite of every care, it usually snapped. We lost three or even four out of every five traps, yet when one disentangled and came up clear, its precious contents repaid all the trouble and loss. Strange marbled moray eels, fish with unusual white patches on their scales, scarlet chaps with eyes unlike those into which the sunlight has ever entered, these and others reward this heart-breaking labor. Radium hooks did their share and even ensnared great pale, wriggling serpent-stars. We successfully caught bottom-fish down to one hundred and eighty fathoms on this watery jungle floor, and hope



Lance or Arrow-crab, which lives among the coral and sea-weeds. *Stenorhynchus seticornis.*

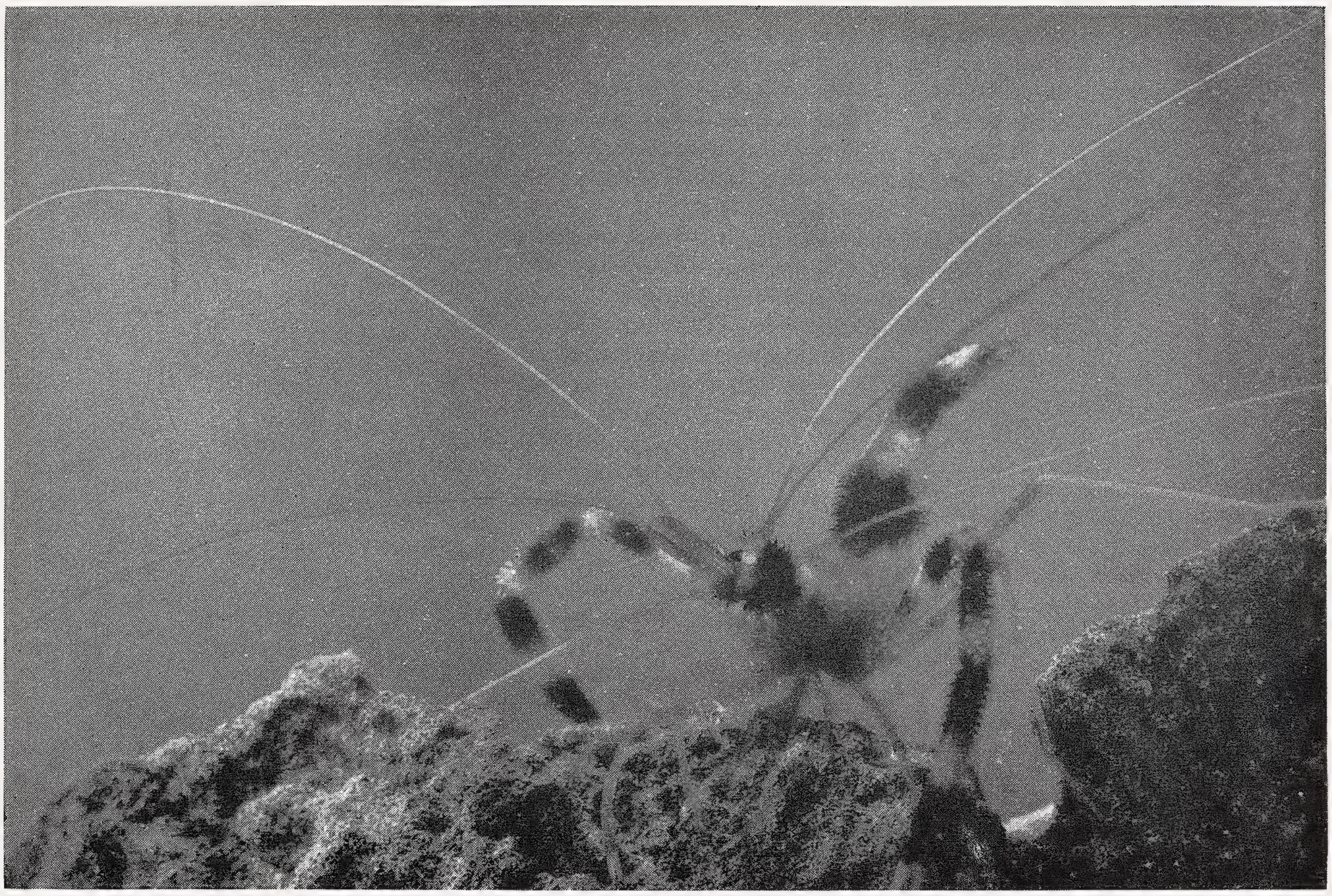
for new ideas and still better luck another season.

Deep-sea Fish.—The deep sea was the lodestone of my interest. The routine of a single day will illustrate our method of work. At six-thirty or seven in the morning the sea-going tug *Gladisfen* steams out from St. Georges and ties up to a buoy off our wharf. From the south look-out, with the telescope, we study the weather conditions at sea, we note the barometer and the direction and force of the incoming swells which shatter themselves on the rocks of Nonsuch. If the surges of the open ocean are too severe, if there is danger of the delicate nets pulling out of their rings, or the wire itself fraying and parting, we signal the tug to go back, if the weather is propitious we snap into the day's action.

With overconfidence in the gods of wind and wave I had hoped at the beginning of the year to pull a thousand nets. When we had completed our six months trawling with the *Gladisfen,* the sturdy tug had been to sea ninety-one times and we had successfully drawn five hundred and twenty-eight nets. This, exactly fifty per cent. of a perfect score, we now realize is an excellent average. Even with a full-sized steamer we would have jeopardized our nets if we had attempted more.

If the sea on the particular day in question is kind, two of us go on board with lunch, crates of jars and printed data blanks. The house flag of the Tropical Research Department of the Zoological Society is run up and the tug churns her way out past the ancient forts, close to Gurnet's Head and due south for five miles. Here with a thousand fathoms of water beneath our keel, we put over the two hundred pound weight and the wire cable is paid out. If I decide on the usual haul we send down six, one-metre silk nets, one hundred fathoms apart, and then sufficient cable to lower them to depths respectively five hundred to one thousand fathoms. For hours we now steam slowly along, at the rate of two knots, watching sea and sky, current, cable and engine.

When the sea is so calm that we are surrounded by slicks filled with Sargassum weed,



Bandana Shrimp, a brilliant, scarlet and yellow species found over most of the seven seas. *Stenopus hispidus.*

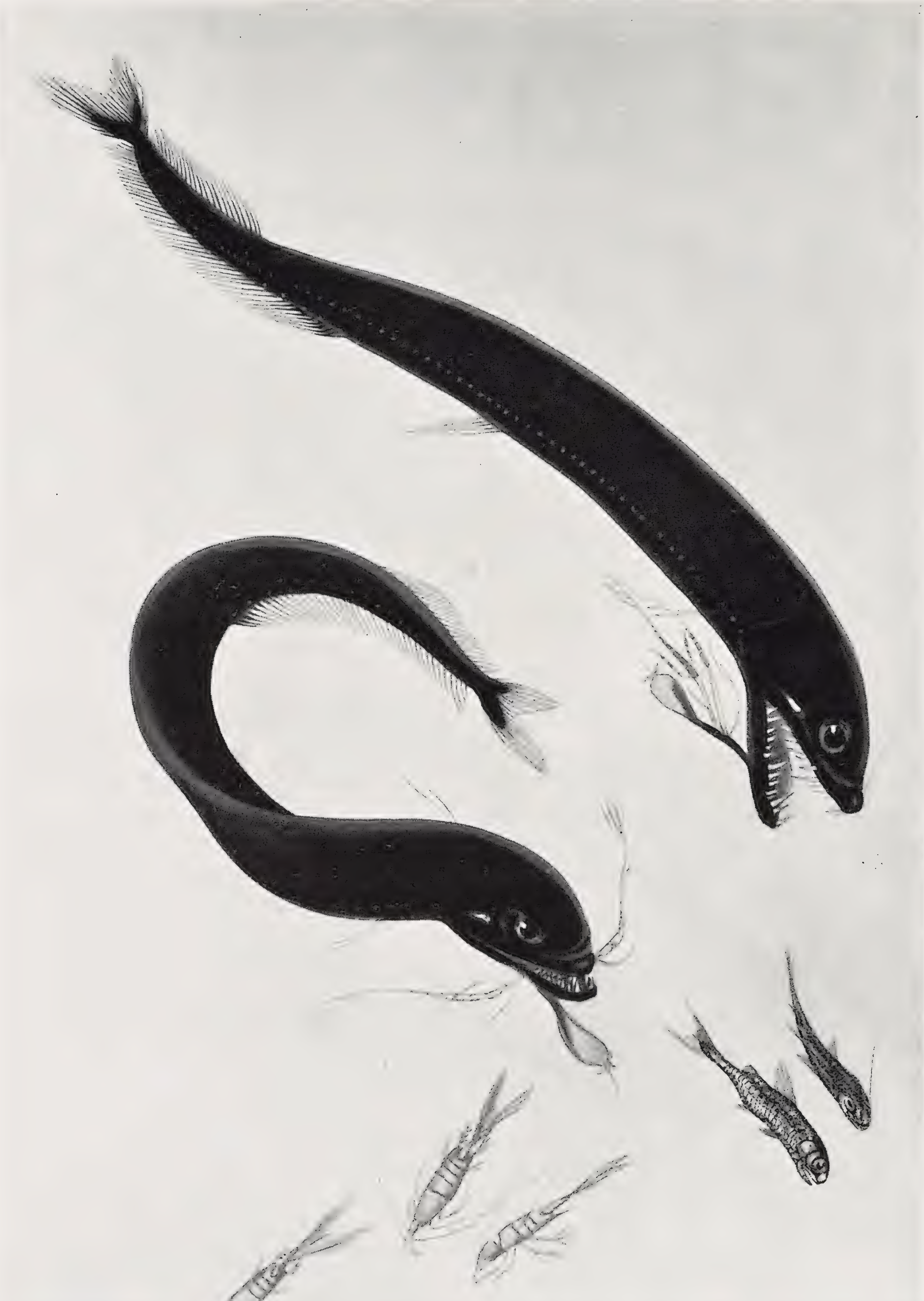
John Tee-Van and I take to a small boat and out-board motor, and successfully pursue with butterfly nets small, gorgeously colored flying-fish. Occasionally I shoot a strange sea-bird, or we hook a large shark or dolphin, and once I just beat a shark to an enormous floating pelagic squid.

One day when we made an especially deep haul I fastened the Explorers Club flag to the lowest net and sent it to a no-mans-land infinitely less accessible than the highest mountain or ultimate pole. It came up icy-cold but showing no hint of the mile and a half of water pressure or the absolute blackness of the ocean's deeps.

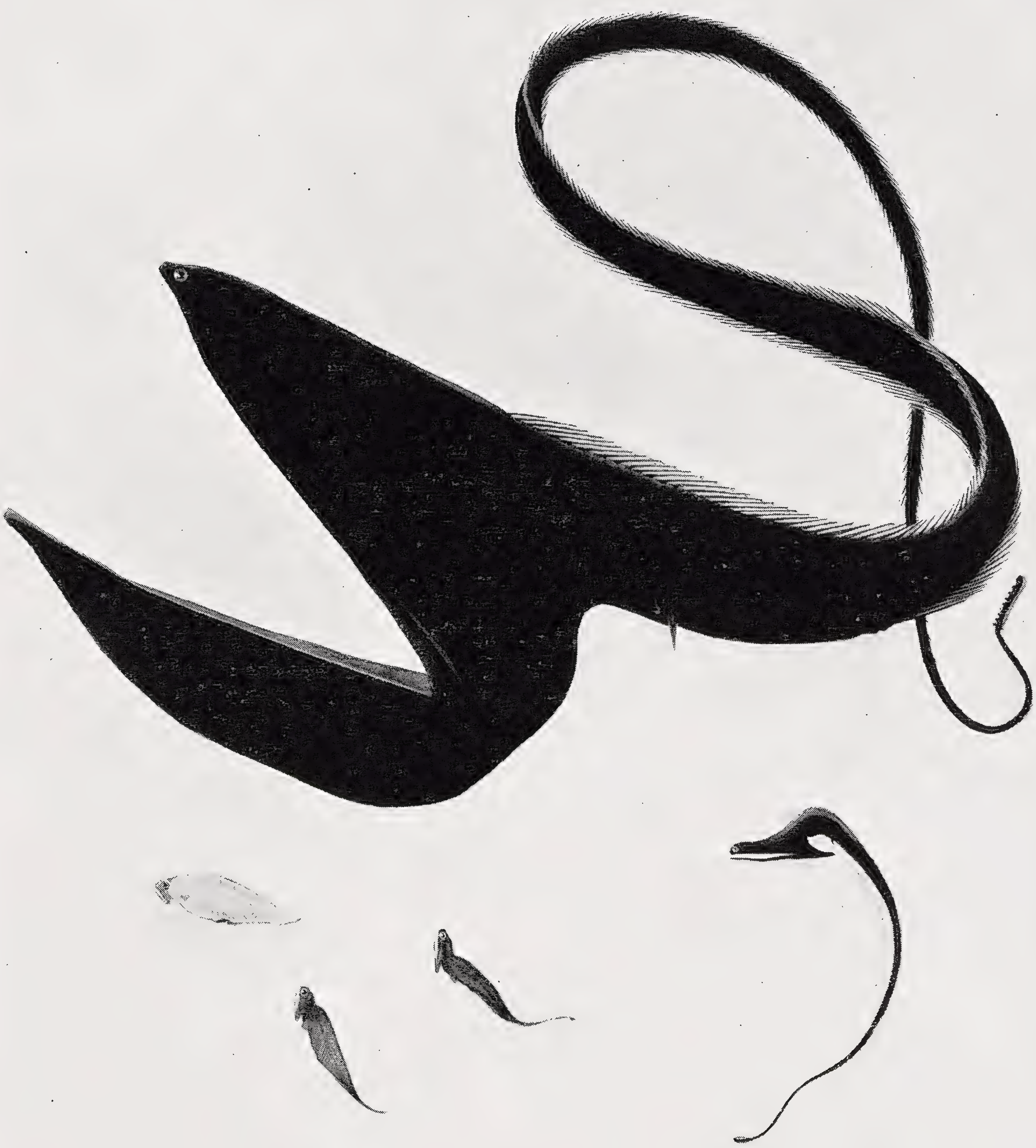
At last the cobweb line is reeled slowly in until a flash of silk is seen far down through the ultramarine depths, and we haul on board the five hundred fathom net. The jar of precious specimens is carefully detached and labeled and the mesh washed for stray fish. When the sixth and last net is lifted in, the tug turns landward and goes full speed for Nonsuch. On the way in, any rare live fish is put in an iced aquarium, while any excess of pyrosma and injurious jellyfish is removed.

The thrill and excitement of the arrival of the catch never abates. A great table is prepared with shallow white containers, into which each jar, full of strange creatures is emptied. The water of the deeper nets is still cold with the eternal chill of a mile below the surface. Each person has special duties. I examine the living, luminous fish and any new form is instantly turned over to the artists who frantically record the colors and tints before they fade. Or they are taken into the dark room for examination. Here they may even be given a slight injection of adrenalin to spur their luminescence to greater activity.

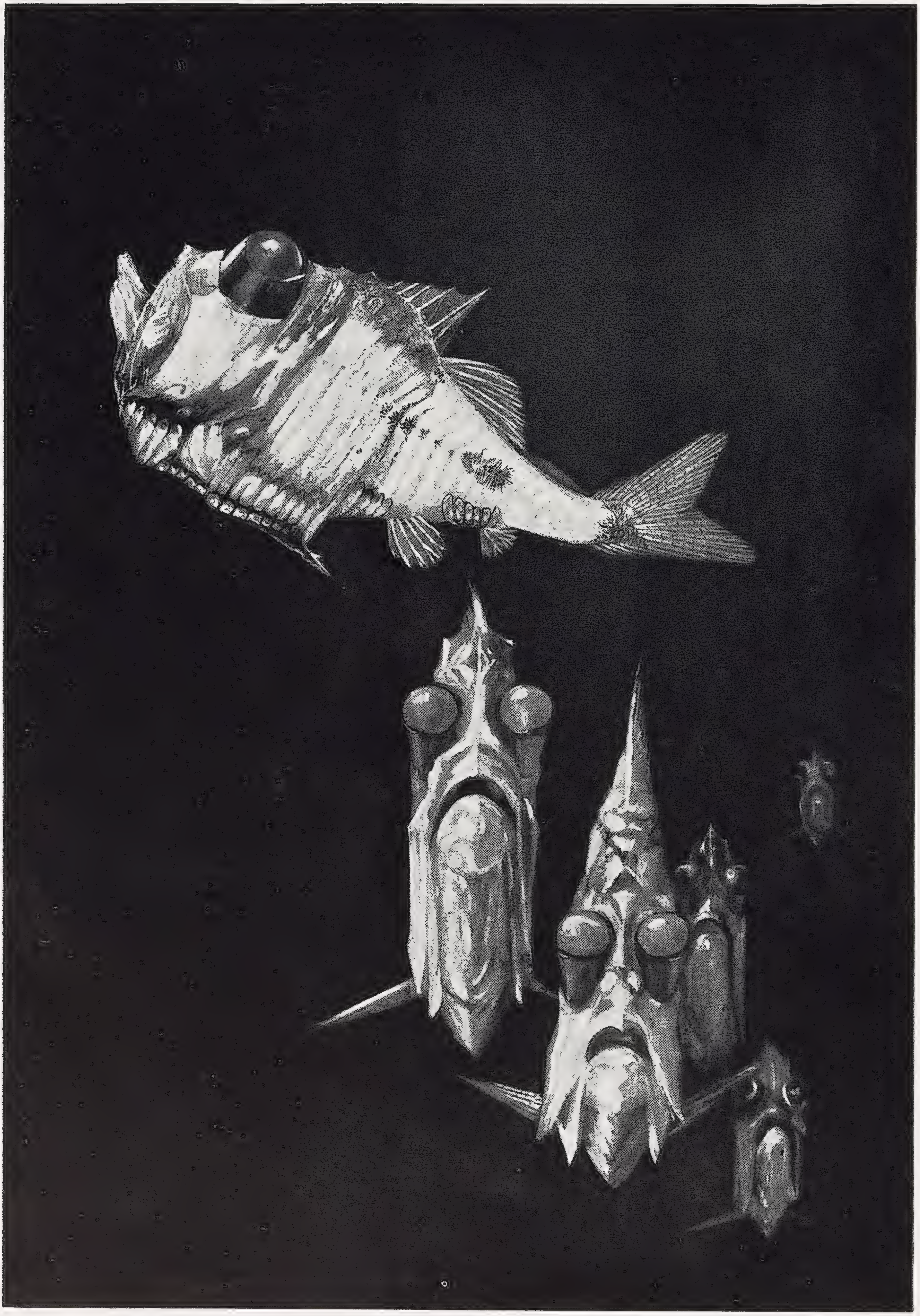
It is during the first hour after arrival that one's mental ability seems to be at lowest ebb. I fully realize the rapidity of the astonishing changes taking place before my eyes. I have twenty glass dishes on my table all holding new and profound secrets, and knowing so well the limitations of my poor brain, I sometimes almost cease my efforts to record so imperfectly



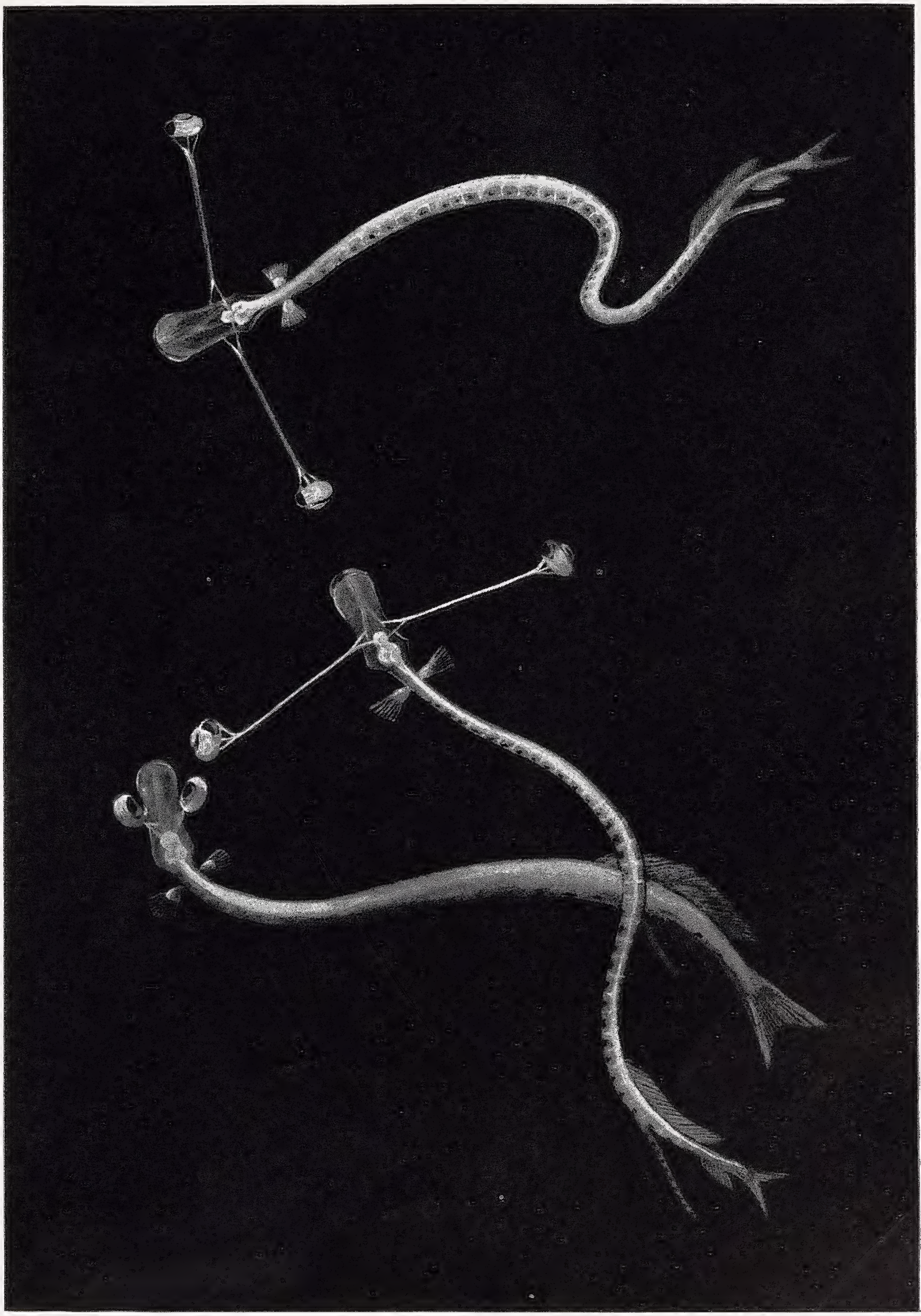
Gold-tentacled Sea-Dragon, a new species of *Eustomias,* pursuing young lantern fish and feather-tailed copepods, at a depth of one mile.
Painting by Else Bostelmann.



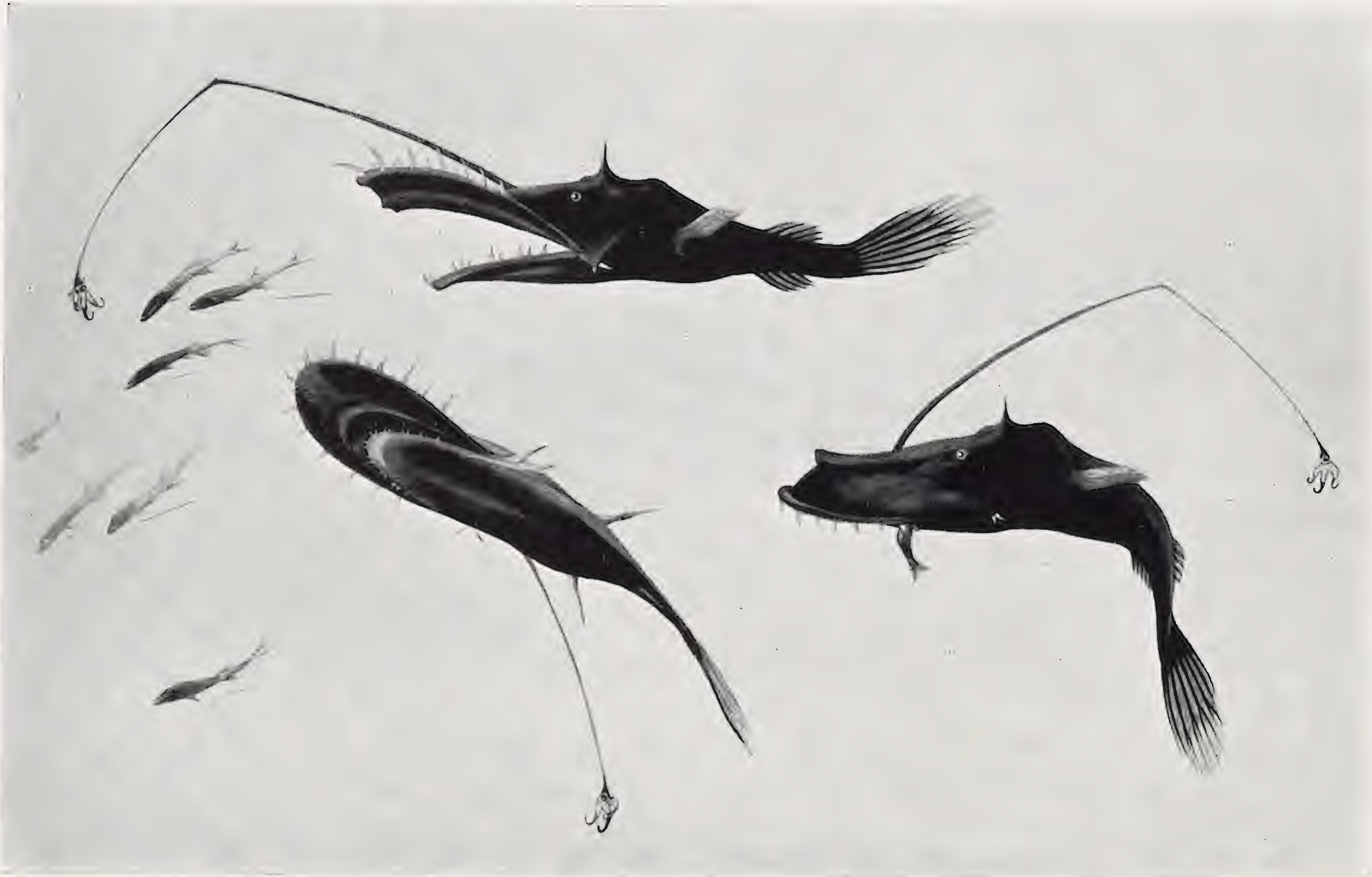
The great Gulper Eel, *Gastrostomus bairdi,* and four of the young phases. Even the transparent, most immature leptocephalid shows the line of ten lights arranged along the tip of the tail. The tiny eyes and skull are at the very tip of the front of the body. Painting by Else Bostelmann.



A common but very marvellous inhabitant of the deep-sea, *Argyropelecus hemigymnus,* the Silver Hatchet Fish, with its telescope eyes looking forever upward, and the group of mauve and violet lights glowing downward. Although living in almost absolute darkness, its body is a mass of iridescent silver. Painting by Else Bostelmann.



A stereoscopic-eyed deep-sea fish—*Stylophthalmus.* It has a row of lights down the body, a great, flat mouth like the bill of a duck, and the eyes on the tips of long cartilaginous stalks. In the young the eyes are sessile. Painting by Else Bostelmann.



Lasiognathus, the deep-sea fisher, with a rod, line, luminous bait and cluster of three hooks. It can cast fore and aft, but probably uses its angling apparatus rather to frighten and confuse its prey than actually to hook them. This is a species new to science. Painting by Else Bostelmann.

what I perceive but cannot interpret. I lean hopelessly back and look with unscientific eyes but a tremendous feeling of awe at the astounding glory of glowing lights and iridescence, and never-ending marvel of a living fish which has withstood a lessening pressure of over a ton upon every square inch of its body, and which in the thin, warm medium of the surface water and the terrible glare of sunlight can still swim and breathe and carry on.

In many ways the deep sea fisherman is comparable with an astronomer—he can scarcely hope to visit and actively investigate the native haunts of his interest. But before I committed my specimens to the mummifying effects of preservative I was able to learn much about them while they were still fresh and icy cold from the depths of ocean.

Perhaps the most important discovery was that temperature was even more important than pressure in keeping them alive. Ten minutes of vital activity to as long as forty-eight hours rewarded our efforts. So I had opportunity for notes on length of viability, character of swimming, shape while still unshrunken, tints of body and color of luminescence, and finally accurate data as to eggs and food.

Fortunately deep sea fish usually swallow their food whole, so in many cases I was able accurately to recognize the last meal. In some future net I was almost sure to find an injured or even living specimen of this food, and this gave me the material for a reliable painting in full action of the particular fish pursuing the prey in question. With the aid of my artist Mrs. Bostelmann, I was able to record half a hundred such tableaux—scenes from the lives of these fish as authentic as though they were photographs taken at a mile depth.

Up from the black depths came huge-mouthed Gulper Eels, creatures almost all mouth with just sufficient muscle and tail to open and close the massive maw and whip it through the water. Then came unforgetable moments when the staff was summoned to view the leptocephalid young of this eel—as unlike the adult as an Indian pipe is unlike an orchid.

Blind fish groped about our pans of abysmal loot, and with them tiny fish with eyes so large that these organs occupied quite half of the entire body. We picked up squids which had their eyes on the tips of long arms, others which showed waves of unbelievable turquoise luminescence flowing around and around their staring scarlet eyes.

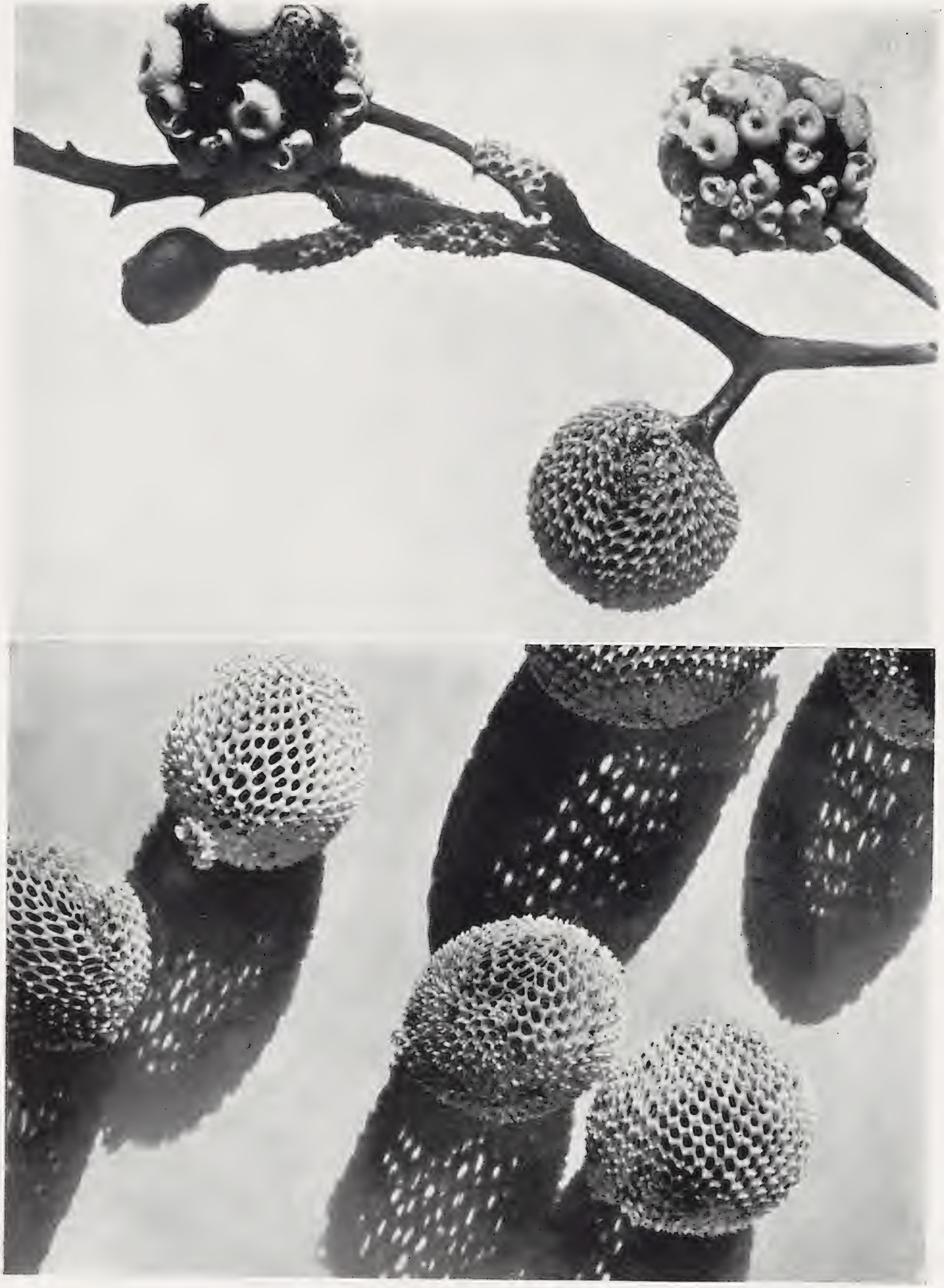
Fish wholly of transparent tissue, of astonishing shape, some with elaborate pigment hieroglyphics along the sides, defied identification, for they were the unknown young of equally unknown adult forms, and we could only describe and photograph them, and give them numbers or casual titles, such as Sextet Bullseye, Ghostfish, or Yellow-throated Blue Dragon Eel.

Two atoms of fish were rescued by Miss Hollister one day and found to be infants of an ocean sunfish which reaches the weight of a ton.

Smooth, scaleless sea-dragons were taken by scores, many of them quite new—and most with fantastic barbels. Some of these appendages were like slender threads strung with pink glowing bulbs, others were branched like a tree, all shining with yellow and orange lights. Great cheek lights were sometimes present, pink or green or mother of pearl, which could revolve out of sight or be suddenly eclipsed by a descending eye-lid of black skin. In one unnamed being, the slender chin tentacle was ten and a half times as long as the entire body, and another big fellow had his skin etched or tattooed with fine lines of pale blue light.

The vital interest of this catch of thousands of deep-sea fish, which contains representatives of almost every known family, is that they came from a vertical zone between five hundred and one thousand fathoms and from a definitely limited eight mile circle. When nearly a hundred nets have been drawn let us say at a uniform depth of eight hundred fathoms across this cylinder of water, the study of their contents will reveal real relationships, as to numbers, age, sex, as to which are prey, which are dominant, what proportion make their living by blind feeling, or by a combination of large eyes and abundant luminescence. My season's catch is a mid-water one, well insulated from surface and from bottom.

Two interesting and quite new experiments were made through the generosity of Mr. L. R. Smith of Milwaukee, who had a powerful pressure tank and a very elaborate and ingenious



An example of beauty in death. A bit of dead sargassum weed: the berries covered with the snail-like helices of a sea-worm—*Serpula*—and the marvellous ivory architecture of moss animals or bryozoan skeletons.

pressure gauge devised and sent to us. The former enabled us to place deep-sea fish under a water pressure much greater than that at the surface. The latter was made to register the depth of the net to which it was attached.

On the next to the last day I took a long chance and lowered a big otter-trawl actually to the bottom. Luck was with me, my wire did not part, and although the net was torn it brought up hints of a wholly strange, new world; one which I hope with my large Arcturus winch and half inch wire successfully to study next year.

On the final day of trawling we made a series of ten vertical hauls with most satisfactory results, the careful collating of the contents serving quite accurately to establish the relative depths of our daily horizontal hauls.

Our work this year was not wholly uneventful. Aside from the sudden squalls, and the near accidents which inevitably accompany such field work, we touched bottom unexpectedly one morning and tore away and lost three nets and one thousand metres of wire. This may have been an uncharted submarine mountain peak or saddle-back ridge. One day our long-suffering winch broke down and two precious weeks were lost while it was being repaired at the government dock-yard.

To the Honorable F. G. Gosling, who is the godfather of all the scientific work ever done in Bermuda, and to Governor Bols we are indebted for a host of kindnesses, and our treatment at the hands of the members of Parliament, the other government officials, the local press and the Furness Bermuda Line was that usually reserved for intimate friends and neighbors.

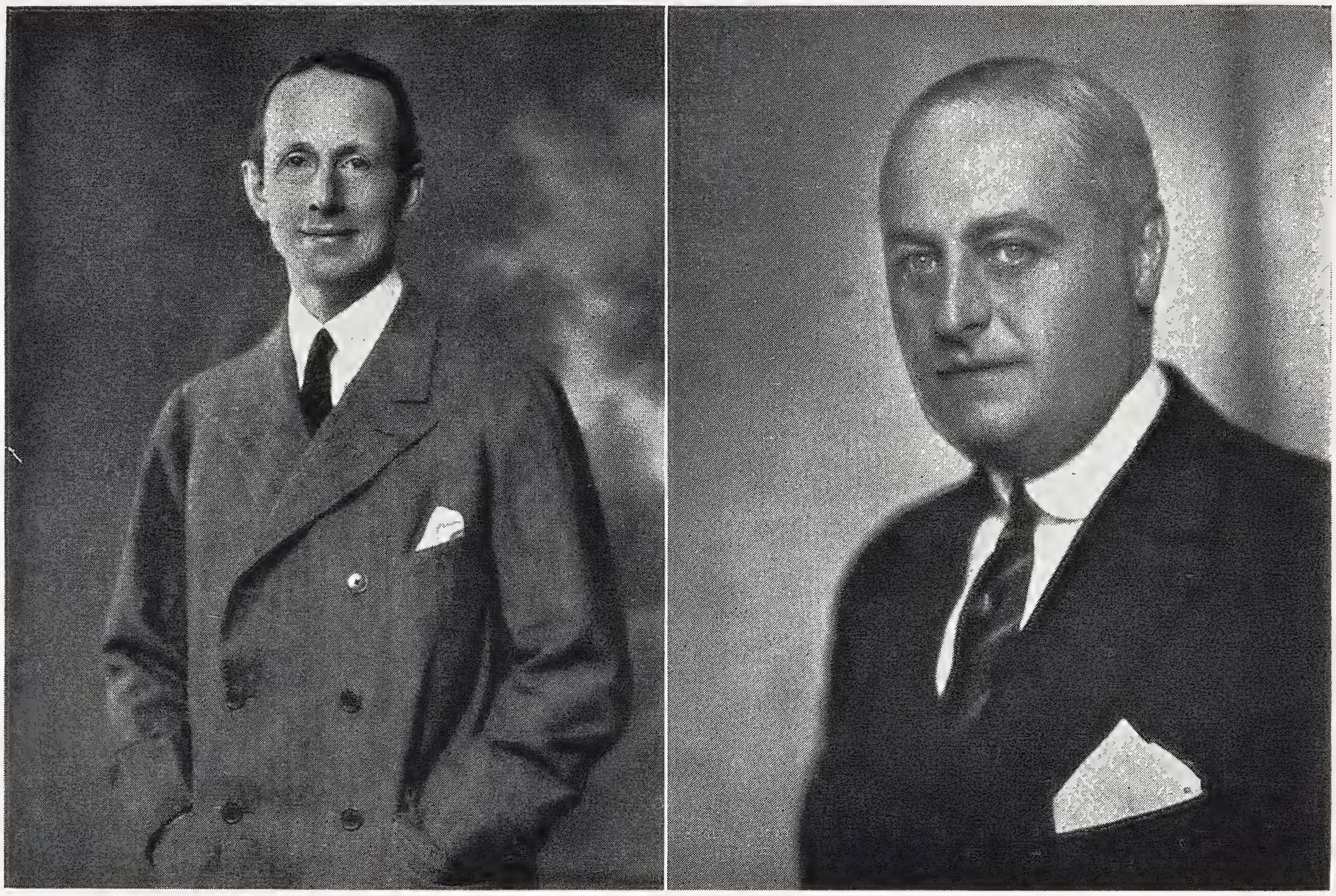
A list of the individual Bermudians who aided our work would consist of almost a census of the island. In St. Georges Mr. W. E. Meyer and Mr. E. Percy Tucker from whom we chartered the tug, did all in their power to make our efforts a success, and provided a picked crew who never lost interest or shirked their monotonous duties. On Nonsuch itself, the government caretaker, Mr. Arthur Tucker and Mrs. Tucker did for us in manifold ways, and accepted our desires and needs as if they were their own.

Laboratory Work.—In addition to the actual naming, cataloguing, labelling and describing of the fish, we carried on research in many directions. Mr. Robert Whitelaw made over six hundred negatives of fish life, as well as landscapes, personal views and general activities. Mr. Tee-Van and I were able to get the first motion pictures ever taken of living deep-sea fish brought up from nine hundred and one thousand fathoms. Mrs. Tee-Van painted over two hundred plates of fish and invertebrates, showing delicate shades of coloring and many color changes. Mrs. Bostelmann made sixty-odd paintings, mostly of deep-sea fish pursuing their prey, and Miss Miller concentrated on the difficult labor of delineating delicate skeletons.

Miss Gloria Hollister took as her major occupation the clearing and staining of fish, and at the end of our stay her collection numbered over one hundred species and five hundred and forty specimens. By patience and the skill acquired during university training and with Dr. Alexis Carrel, Miss Hollister was able successfully to go far beyond her work in New York. The stains used were not only those for bone, but for cartilage, scales, connective tissue, and finally a selective fat stain for non-luminous tissues.

Professor J. Newton Harvey of Princeton spent a month with us working on luminous tissues, and the physiological effects of adrenalin. The luminous organs of fish and shrimp blazed up in the dark-room, and afforded excellent opportunities for detailed study. Dr. and Mrs. C. J. Fish of Buffalo brought two trained workers in wax, who collected and modelled a complete coral reef group. Dr. and Mrs. Fish worked on plankton and larval fish respectively. William Merriman has been with me on every trip and here he attained splendid success in setting baited traps in intermediate depths, at the same time assuring the smooth running of all the delicate machinery, dynamos, pumps, and engines. Five members of the staff were able to spend only part of the time at the Station, Dr. Jamie Jamison, Mrs. Hayne Boyden, S. Von Hollberg, Mary Vander Pyl and Alice Wright.

This staff taken as a whole was the best I



Mr. Harrison Williams and Mr. Mortimer L. Schiff, members of the Board of Managers of the Zoological Society, who have made possible the two Bermuda Oceanographic Expeditions.

have had for years, and it is to their keen enthusiasm and indefatigable labors that the unusual success of the expedition is due.

A number of the members of the Zoological Society and of the Explorers Club visited Nonsuch and we had many other appreciative guests. Among these were H. E. the Governor Sir Louis Bols and Lady Bols, Admiral Sir Cyril and Lady Fuller, Hon. F. G. Gosling, Prof. and Mrs. Henry Fairfield Osborn, Dr. E. L. Mark, Dr. Sayles, Mr. Grant Mitchell, Senator Frederic C. Walcott, Mr. and Mrs. Lister Carlisle, Mr. and Mrs. C. Ledyard Blair, Mr. and Mrs. Burt Massee, Mr. and Mrs. Paul Hammond, Mr. W. E. D. Stokes, Jr., Judge W. F. Mountain, Count and Countess Von Luckner, Dr. and Mrs. Mees, Mr. and Mrs. W. J. Love, Mr. G. P. Putnam, Mr. Carveth Wells, Dr. and Mrs. Henry D. Lloyd, Mr. James B. Pond, Mr. Robert Blackman, and Col. McClaine. Dr. W. Reid Blair owing to lack of time got no nearer to us than Hamilton and Government House. Major Vivian Drake and Mr. Gillmore Browne spent some weeks with us.

During the seventeen years I was building up and caring for the collection of birds in the Zoological Park, I was able to welcome the members of the Society to those exhibits. Now for the first time since I founded the Department of Tropical Research, on the coming Thirteenth Expedition, I am able to extend an invitation to all the members of the New York Zoological Society to see our work in the field.

During 1930 we shall occupy the island of Nonsuch from April to November. In forty-eight hours from New York City one can be in St. Georges with its comfortable hotels, within twenty minutes by motor boat of Nonsuch. Judging by the enthusiasm of the guests we had this first season, the sight of the deep-sea catch coming in is well worth a trip to what the natives call the "Isles of Rest," but which to us mean a most rare opportunity for hard, creative work. We have an extra helmet especially for guests who wish to dive among the coral reefs near the island. The variety of suitable spots is so great that the diver can be certain of taking his plunge with or without sharks.

Mr. Madison Grant,
330 Park Ave., New York, N. Y.

United States Senate
Washington, D. C.

My dear Mr. Grant: I am taking this opportunity of sending you a line of commendation on the work of Dr. Beebe and his staff on Nonsuch Island, Bermuda. As one of the trustees of the Zoological Society I am greatly interested in the success of our scientific work in the field.

I spent a week on Nonsuch last summer, diving and photographing under water, and watching the deep-sea catches and researches.

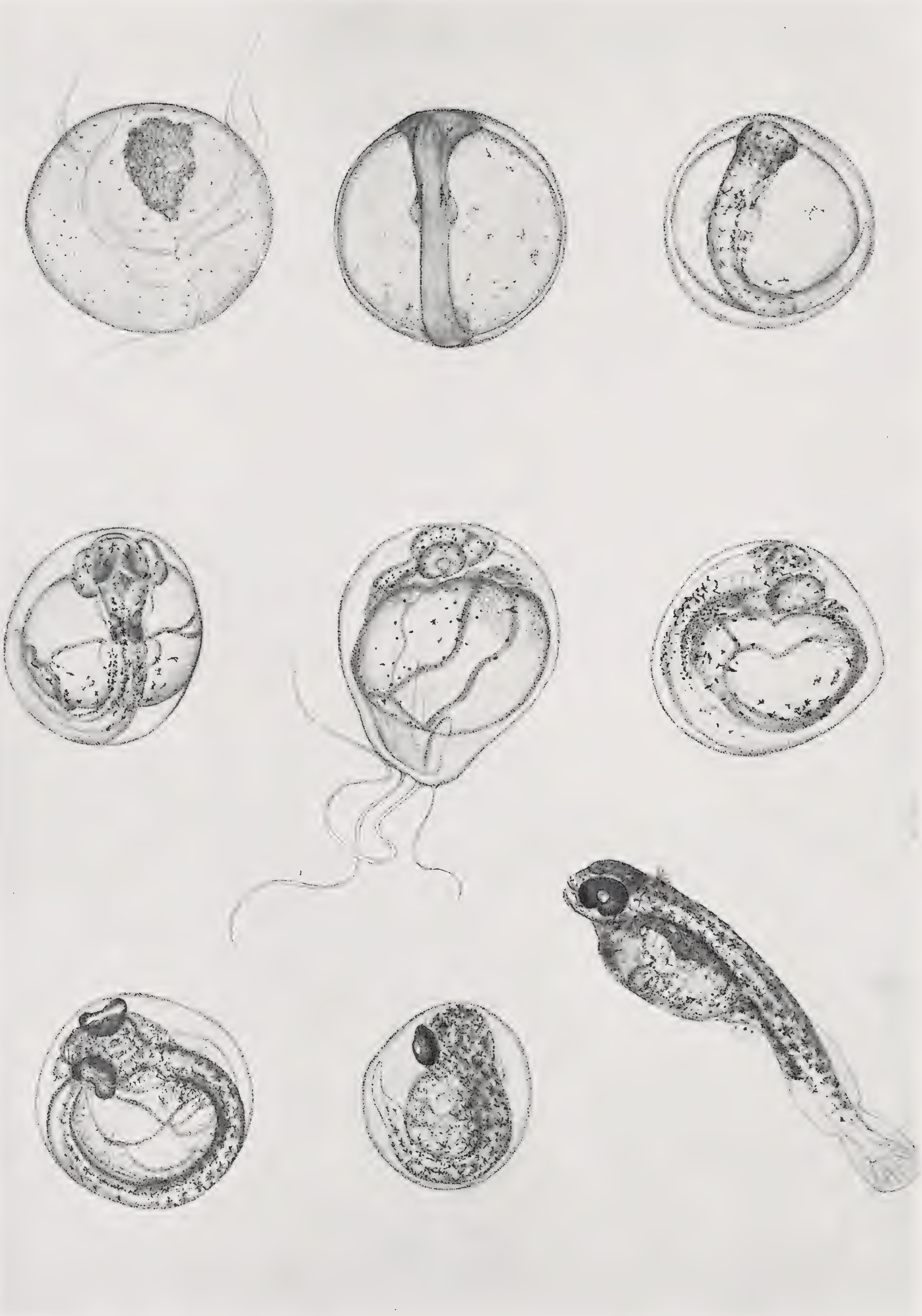
Our Director, William Beebe, is extraordinarily well equipped to delve into the mysteries of the ocean depths and introduce his various exhibits to the public in his inimitable way. He has a scientific background which enables him to get the facts. He has collected a group of enthusiastic assistants who can analyze, classify, photograph, sketch, and systematize these living curiosities in such a way that they help materially in piecing out the chart of life. Dr. Beebe, as you know, has great facility in describing these specimens and some of the lessons they teach in a graphic, popular way, which is in my opinion, of really great value in addition to the purely scientific merit of the work that is being done. I hope the popular side will never be neglected. I wish that other lessons of biology and physics were being presented in the same fashion, so that the lay mind could understand something of these wonders.

It may be irksome and difficult to present scientific facts to the public in such a way as to stimulate interest in pure science and a desire for greater knowledge of it, but it is the highest form of education; and when a man has the gift of presenting facts in popular form, that gift should be exercised to the limit.

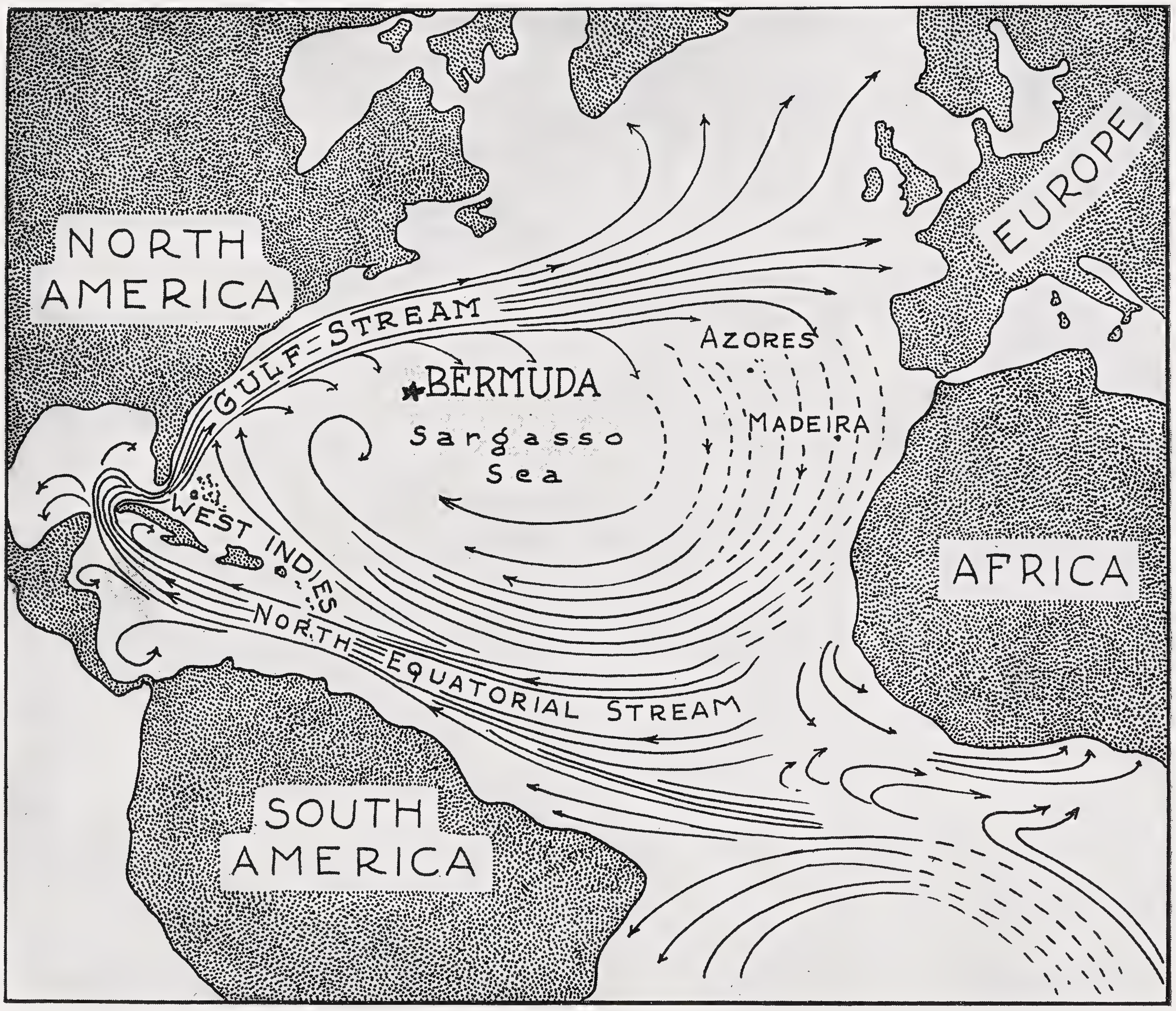
Sincerely yours,

FREDERIC C. WALCOTT.

Prof. Henry Fairfield Osborn and Senator Frederic C. Walcott photographed during their visit to Nonsuch.



Eggs of Flying Fish, showing late development and hatching as observed in a laboratory aquarium on Nonsuch. They were taken from a nest bound together with strands of silk in a bunch of Sargassum Weed. Painting by Helen Tee-Van.



Sketch map of the North Atlantic Ocean, showing the relation of the great oceanic currents to Bermuda. Adapted from Johnstone's "Introduction to Oceanography." Drawing by John Tee-Van.

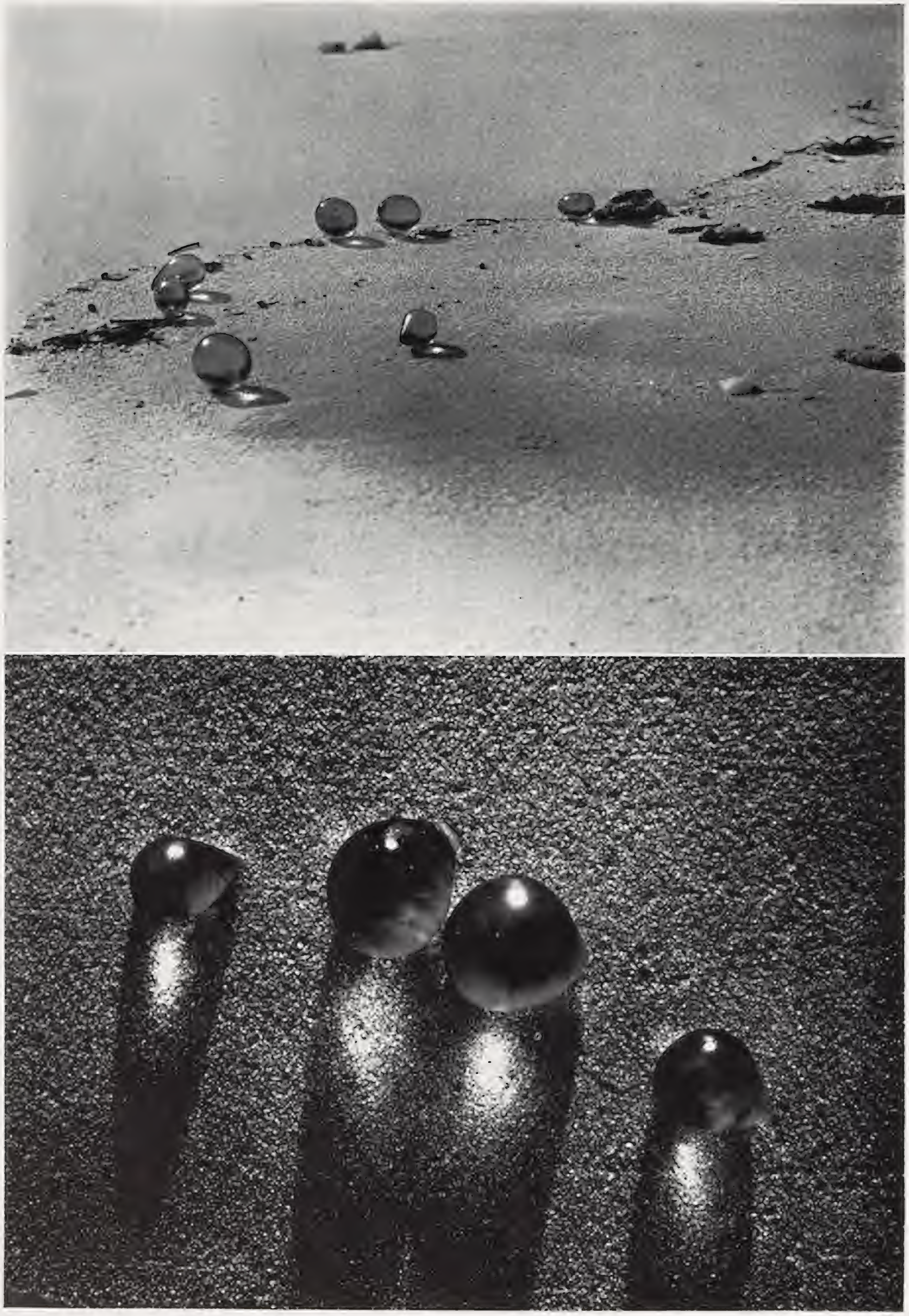
How Bermuda Acquired Its Shore Fishes

John Tee-Van

ALONG the sandy beaches of Bermuda during most of the summer and autumn months, great mats of Sargassum weed are found, either hurled ashore by breakers or floating in the shallow waters of protected coves. The weed, in its contact with the island, serves a double purpose—the first utilitarian, for it is much desired as fertilizer by the Bermudian farmers, the second not as practical but of far greater interest. For in this case it points at the beginning of things—it shows the way in which Bermuda, an island situated many hundred of miles from other land, and jutting abruptly out of water a mile and a half to two miles deep, acquired its shore fishes.

In among the fronds and gas-filled floats of the Sargassum are infant fishes, small triple-tails, tiny amber-fish and ale-wives, rarely a sea-horse, pipe-fish, and always the ever-present voracious Sargassum fish. Some of these, especially the last two, are permanent inmates of the weed, spending their lives clinging to the fronds and insinuating themselves through the interstices of the algae. The others, usually much fewer in number, occupy it as a nursery, gaining protection for a short period of their lives when protection is most needed.

Thousands of years ago similar weed must have drifted in to Bermuda, bringing with it its cargo of babies. Besides the weed the currents



The largest single cell in the world—a one-celled alga, *Valonia,* locally known as Sea Bottles. These look like giant emeralds, and are washed ashore on Nonsuch beaches. The Rockefeller Institute has, for four years, maintained a station in Bermuda for the sole purpose of studying this type of single cell.

brought eggs in various stages of hatching, and other small fish, who with greater courage or with less intelligence or without thinking at all about it, declined to avail themselves of the safety of the Sargassum. Now and then an adult fish may have lost its moorings, and, caught up by the currents and wafted along, eventually—one cannot say landed, reefed at Bermuda.

Countless numbers of fish both large and small, must have drifted during almost countless years near the coast of the island, and only by the accident of being a few hundred feet farther one way than the other, have an infinitesimal number reached the actual shores. Of the relatively minute number that were fortunate enough to gain the protection of the reefs or bays or protected pools, an even smaller number were able to find the exact niche to which their ancestors had been accustomed and that meant life and the opportunity to exercise their abilities to maintain that life.

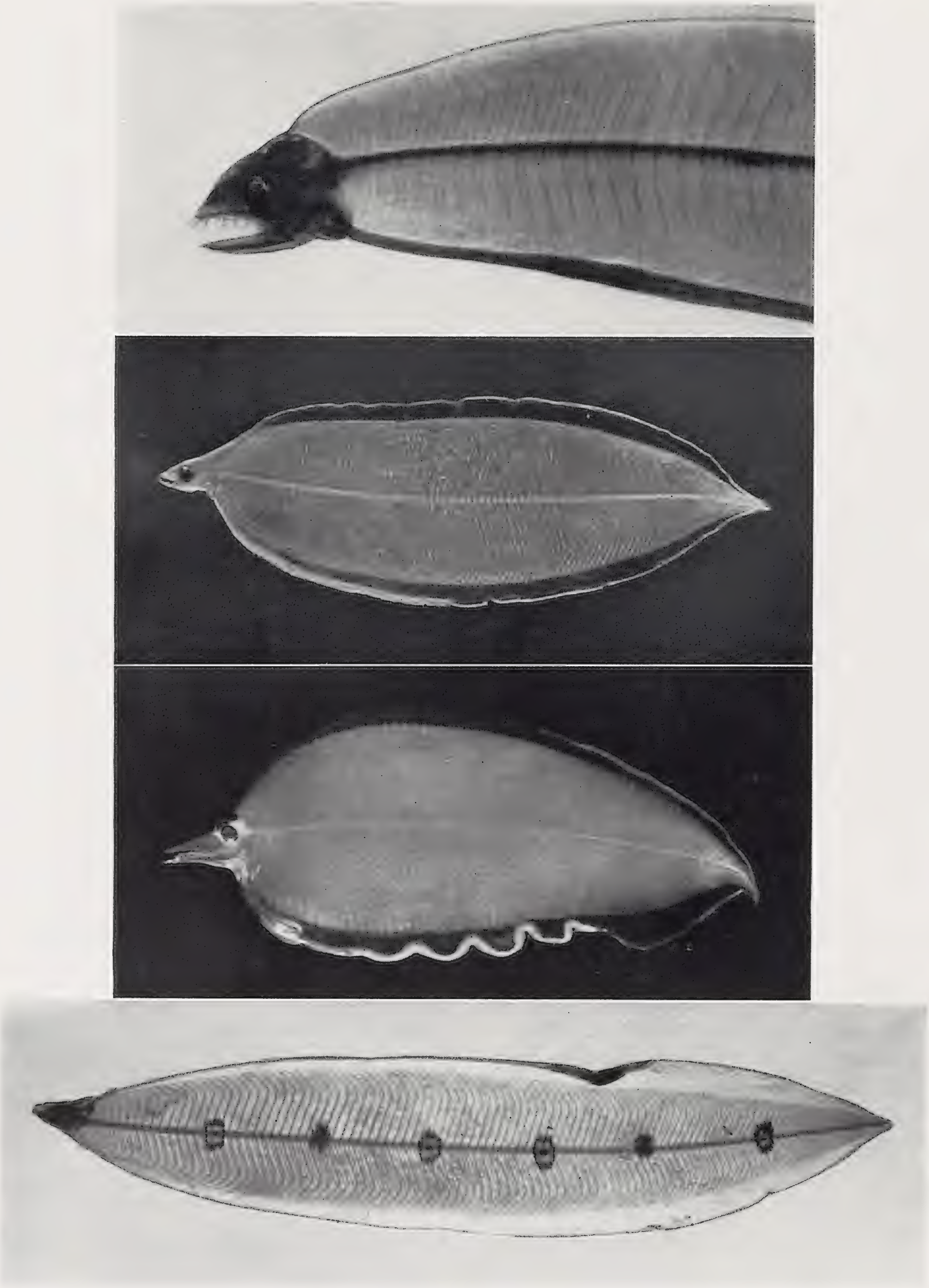
That conditions were not always favorable to the establishment of a certain species of fish is attested at the present day by the Triple-tails, which although the young are abundant in the weed, have evidently not been able to maintain themselves in the conditions offered by Bermuda. During our eight months' stay in Bermuda in 1929, no adults were seen and our native fishermen did not know the fish at all. Other fishes very likely have similar unknown disqualifications.

But to come back to our weed and the eggs and fishes and where they drifted from. If we look at a map of the North Atlantic ocean that shows the current systems, it will be seen that Bermuda lies well outside the main current of the Gulf Stream, and that the full force of that rushing body of warm water is not felt at the island. It is quite evident that eggs and fishes that are in the central part of the Stream must inevitably be carried far past Bermuda, so that it is only by the accident of their being in the southern and eastern borders, where by the action of the induced currents they might be carried farther and farther away from the central rush of water and eventually be transported to the quieter currents that surround Bermuda.

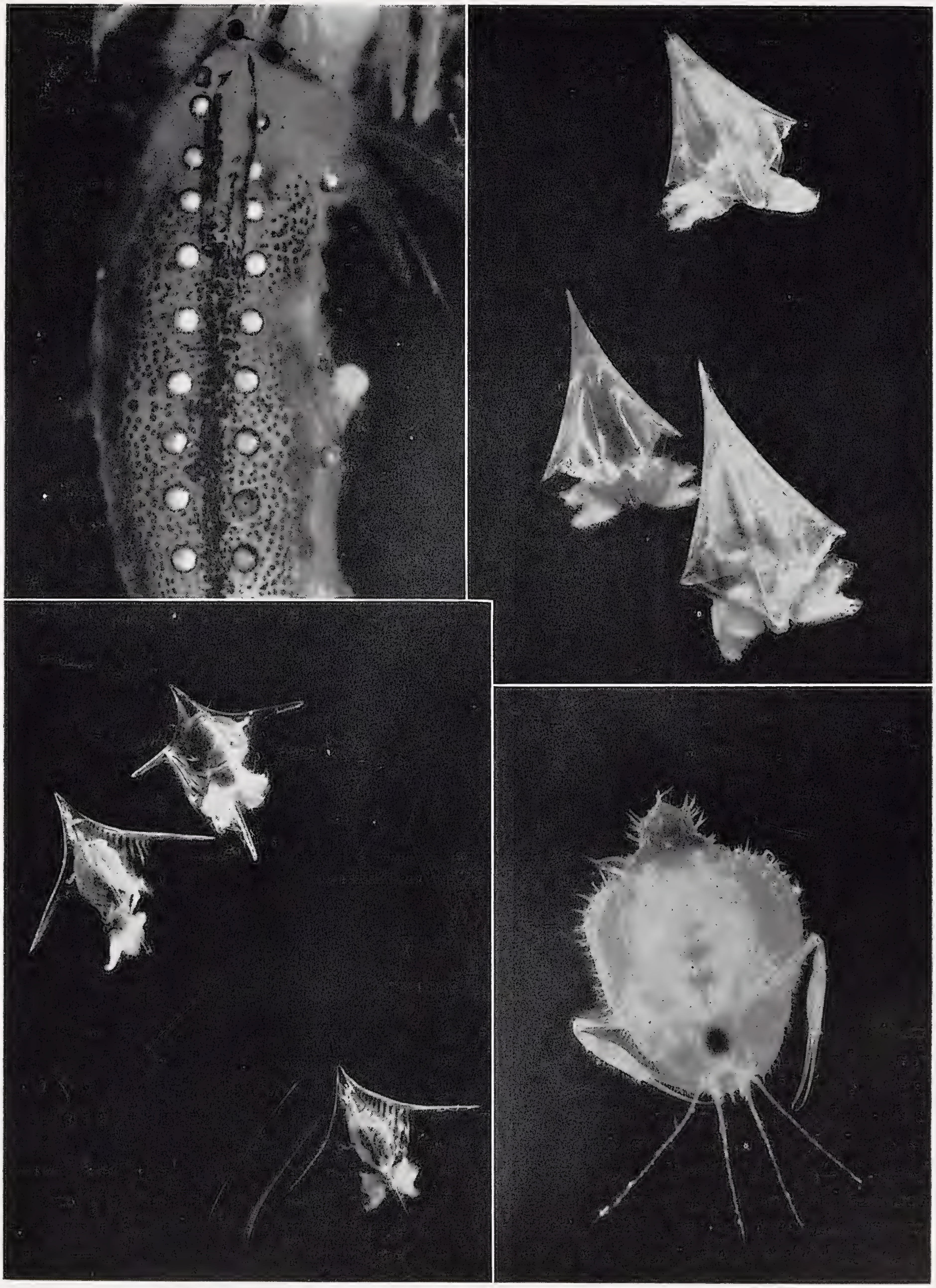
If we follow these currents backward we can find where most of the fish of Bermuda came from. The journey back is not a long one, because we soon find that the close relatives of the Bermuda fish are to be found among the West Indian Islands and along the coast of the Southern States, Central and northern South America. In fact most of the species are exactly the same. But in some species the interval of time since the nth grandparents first arrived on the island and the present generation appeared, has been so great that the Bermudian fish have changed slightly from their West Indian cousins. A few scales have been added here and a few lost there, another spine or ray may have been added or lost, or colors may not be quite the same. The silversides, *Atherina,* show this as well as any other form, and quite a number of other species demonstrate it as well. Bermuda has been called a sub-region of the West Indian fish fauna, and it is certain that further work will tend to establish this region even more firmly.

If we investigate the Bermuda fishes more carefully, we will find that there are a few species whose nearest relatives are members of the European fauna or live about the shores of the Azores and Madeira. Even the presence of these can be explained by the currents. If we study our map of the North Atlantic again it will be seen that the currents form a great circle which flows clockwise and that on the eastern side on their southward journey they pass the shores of Europe and the Canaries and Azores, before turning westward to become warmer and enter once more the waters of the Caribbean and then eventually become once more a part of the Gulf Stream. A branch of this same westerly flowing current joins the Stream above the West Indies passing north of the Bahamas. It is quite probable that these fish came to Bermuda from their Eastern Atlantic homes by this long and devious route.

But even the currents and drifting can not explain all of Bermuda's fish. At the present time there are a number of species that are known from nowhere else, and the explanation of the fauna having drifted there apparently would not apply to these. But the number of these unique forms is constantly dwindling as our knowledge of the West Indian fishes in-



The transparent larvae—or Leptocephalids—of unknown species of eels; trawled at great depths in the open sea off Nonsuch.

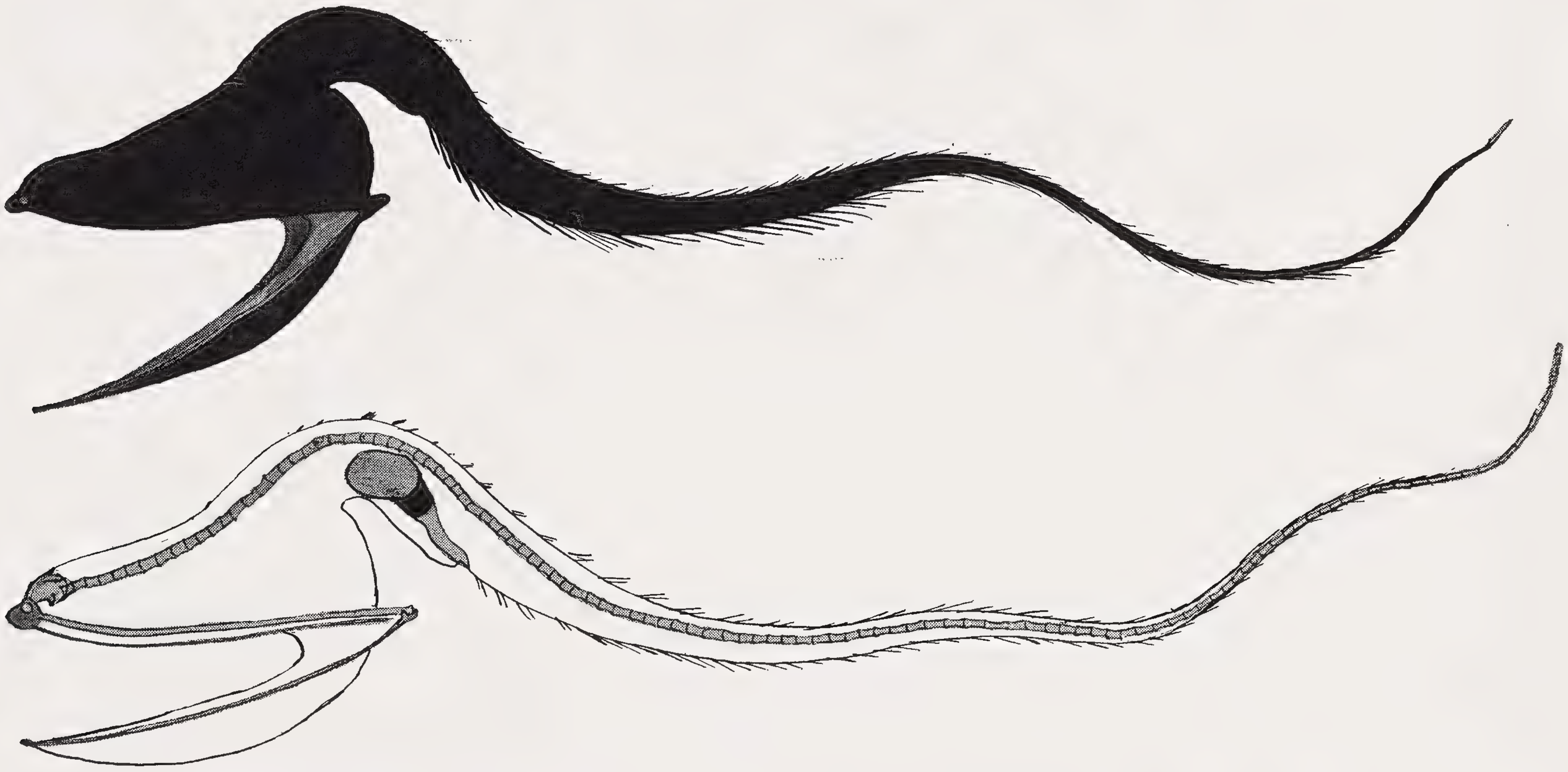


Upper left: The facetted body lights of a deep-sea fish, *Cyclothone*. *Lower right*: A delicate, glassy, deep-sea shrimp—*Eryoneicus*, a very primitive crustacean, related to fossil forms. Remaining photographs: Arrow snails or Pteropods of the genus *Clio*, swimming far beneath the depth at which light penetrates.

creases and very likely most if not all will be found to be common to the two groups of islands. Some of them, however, as a few of the pipe fish and wrasses, may have developed since the introduction to the island of their ancient prototypes.

Certain species and most desirable ones, too, perhaps never could have reached Bermuda. Some undetermined or indeterminate factor, such as non-floating eggs, or inability to maintain themselves during the long journey from their homes to Bermuda, has militated against their arrival. A few of these have been helped along by man, and it is to the enterprise of Mr. Louis L. Mowbray of the Bermuda Aquarium that the island is indebted for a few of the choicest of West Indian fishes that now swim about her reefs.

And so even as we watch the Sargassum weed advance and recede as wave after wave attempts to push it farther and farther up the beaches, and troublesome as it may be to the propellers of our motor-boats, its presence near an island where it does not grow, indicates for us a possible way in which the fishes of Bermuda came to their delightful island home.



The Gulper Eel, shown as the normal fish appears, and as a transparent object.
Drawing by Llewellyn Miller.

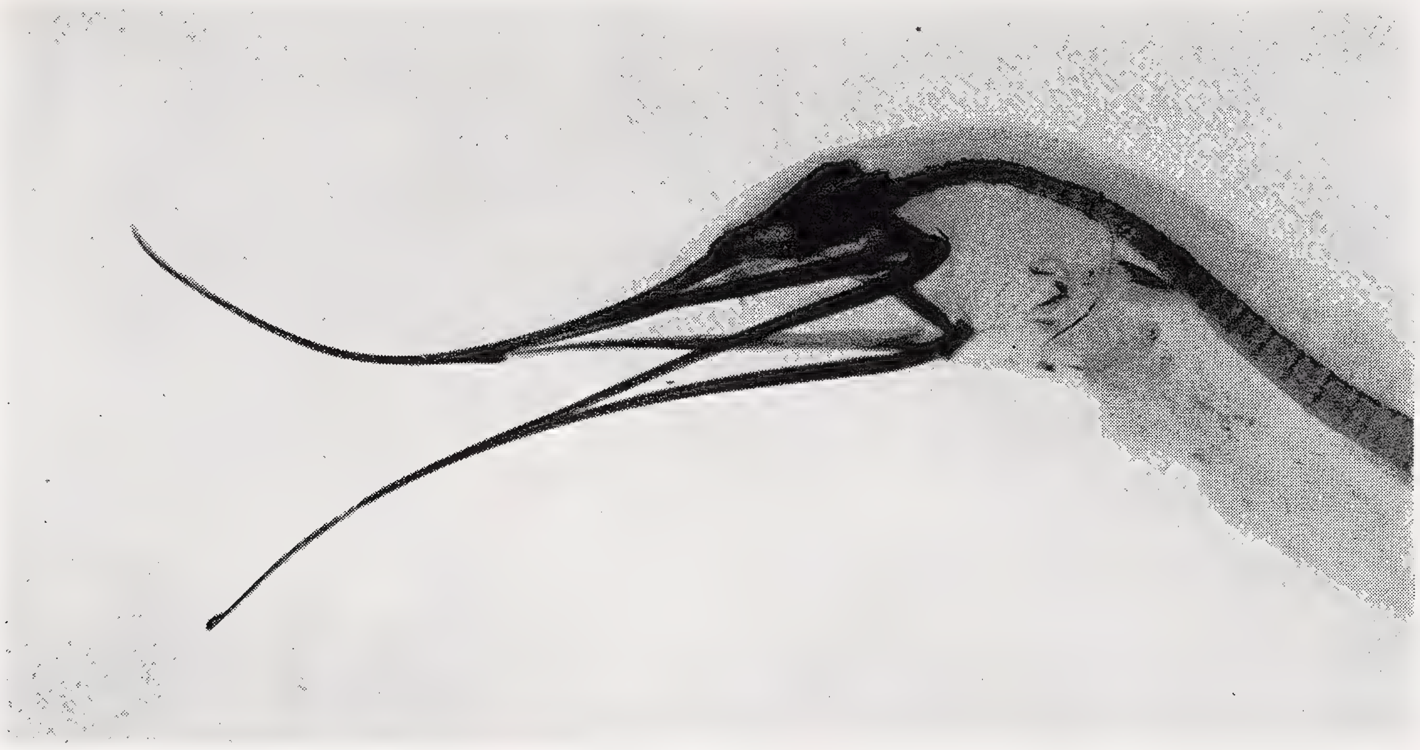
Fish Magic

GLORIA HOLLISTER

IT matters not whether fishes are rare or common, or by what means they are caught, each one is studied at Nonsuch. The future of every fish is decided by the scientific judge according to its individual value. Some are destined to be purely utilitarian and, after the content of their stomach has been recorded, they are consumed by hungry fish connoisseurs. Many times we envy the chef his comparatively simple problems of preparation, seasoning and cooking, after which the fish achieves the worthy destiny of providing perfect nourishment for our bodies.

Less satisfactory are the results in the case of the other fish which prove subjects for scientific investigation, zoological research and chemical preparation. The problems here are so complex, so intricate, that only too often must we admit mental indigestion when we have done our best.

The chemical preparations have proven remarkably successful. With an abundance of material and splendid laboratory quarters and equipment and an able assistant—Miss Alice Wright—I accomplished much of what I had planned. The technical laboratory is known intimately as "The Clearing House"—for, in addition to clearing fish, mental opaqueness often is clarified by noisy discussions. The



Head of *Cyema*, a rare deep-sea eel, with the bones shown by our clearing process.

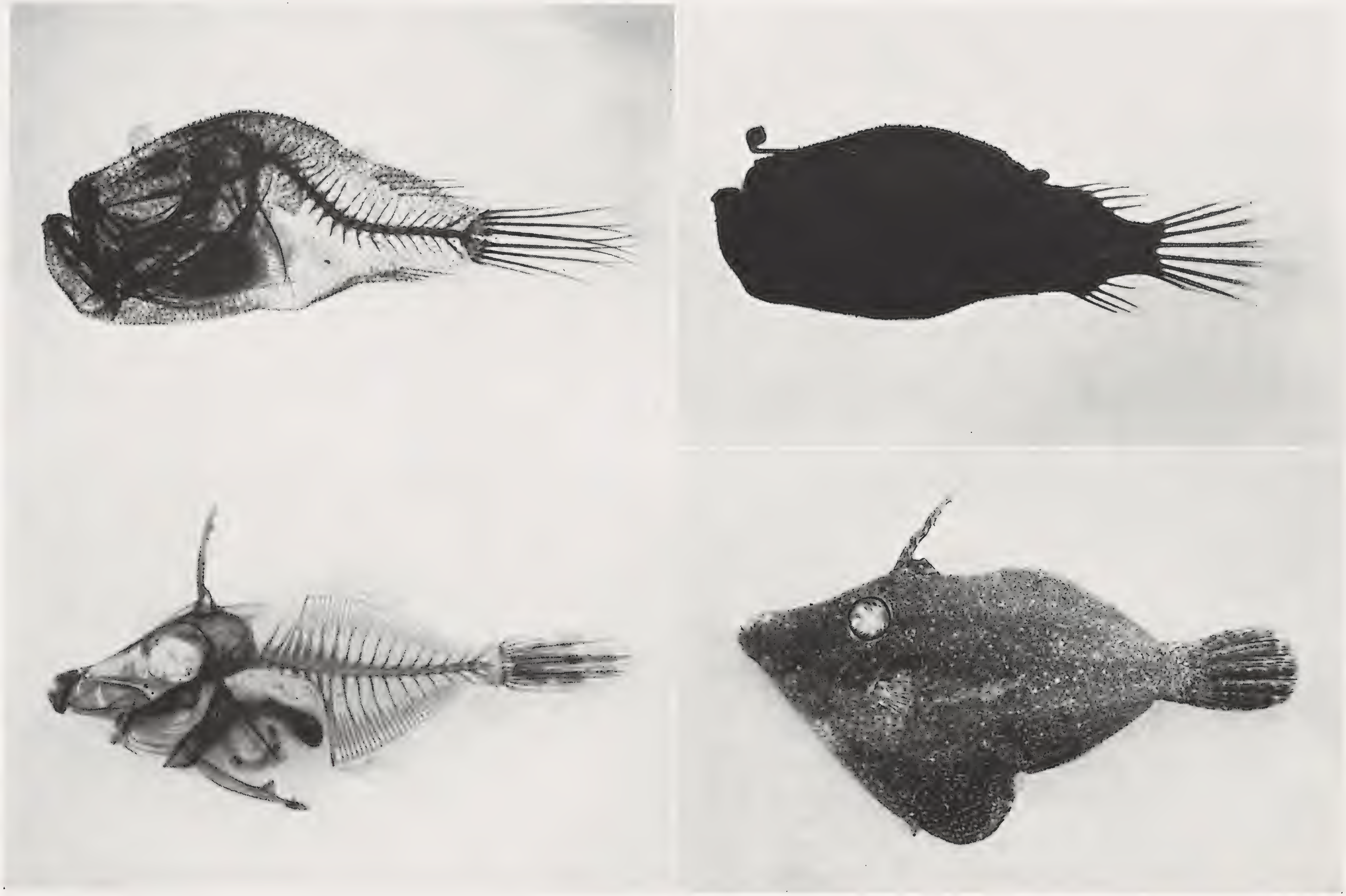
Bermudians have named my laboratory "The House of Magic." History recalls that not many years ago a woman was burned to death on St. David's Island near by, as a witch, for working minor magic; I could easily qualify if those days were not past.

By the mysterious working of brilliant dyes, bleaching fluids, and other chemicals, we find that beauty is not merely skin deep. Every bone, tendon, muscle and fiber assumes an individuality, with a characteristic pattern. Like the fading of one cinema picture and the gradual appearance of another, the skin and flesh of the fish become less and less opaque before our eyes, while the skeleton, stained a brilliant scarlet, crystallizes into plain view. Specimens treated by these processes, whether man, bird, frog, or fish, adult or embryo, remain natural in size, shape and structure. No dissecting knife has touched them. But their bodies have become transparent and their concealed structures colored to increase visibility for study. The specimens are permanently preserved and ready at any time for osteological, histological, and ecological study. Distinct photographs can be made of the skeleton, showing the degree of development of bone and the centers of ossification.

We know, of course, that X-rays also have the power of penetrating objects which are opaque to ordinary light. But in this case the photographic plate must be studied and not the original specimen. We must depend on the accuracy of the emerging rays to radiograph a shadow picture on the photographic gelatine. The result is often blurred and detail of structure lacking. For the purpose of anatomical research on non-living specimens this process of "clearing and staining" far excels the tedious method of old, of dissecting out the desired parts. Photographs of the actual skeleton of the "cleared and stained" fish are immeasurably better than X-ray plates taken of the normal fish.

During the summer I experimented with newly caught fish as well as those which had been preserved for a long time. This showed, to my surprise, that the final transparency of a *fresh* fish gave more perfect and more brilliant results. With delicate treatment the fresh tissues were uninjured and reacted more readily to this artificial staining and clearing than did those of the preserved specimens. This was contrary to the experience of other zoological chemists. It was almost unbelievable to see the scarlet skeleton of a small trigger-fish, apparently suspended in mid-fluid, with the remainder of the fish wholly invisible—and to remember that only twelve hours before, the little fellow had been swimming, happy and opaque, about his home near a Bermuda coral reef. As far as I know this is a time record for producing a perfectly stained and cleared transparency.

We gaze at the sharply defined scarlet skeleton, within an almost invisible outline and won-



The Black Whalelet, *Ceratias,* a deep-sea fish, cleared and natural.
Trigger-fish, *Monacanthus,* a shallow water fish, cleared and natural.

der what power has produced this amazing transparency. But neither chemist nor physicist has wholly solved the secret. As a magnet attracts iron filings, so the bones draw to themselves the particles of alizarin dye and only an acid bath can break this bond. Immersion in alizarin for a few hours is sufficient to dye all the bones a uniform scarlet. The rest of the body takes on a paler stain which necessitates a series of bleaching baths before the real clearing is begun. The affinity of alizarin for bone is almost incredible. Even the blackest black skin of a deep-sea fish can be bleached and yet the scarlet stain still remains in the bones. Other dyes can be used to stain the skeleton but no other will resist the decolorizing process which follows the staining. This is the great difficulty of such delicate technique applied to whole specimens, a difficulty which, of course, is never encountered in the staining of thin microscopic sections.

The bleaching of the skin and the removing of the dye from the tissues other than bone is accomplished by a series of peroxide or ammonia baths or some other non-acid fluid. Short exposure to sunlight is effective for delicate specimens only, but this is not under laboratory control and is often unavailable at the moment when most needed.

The completion of the decoloration is accomplished by soaking the specimen in various dilutions of potassium or sodium. For very delicate fish, larval forms and embryos, sodium gives better results, being less potent. We have used other solutions but these are most satisfactory.

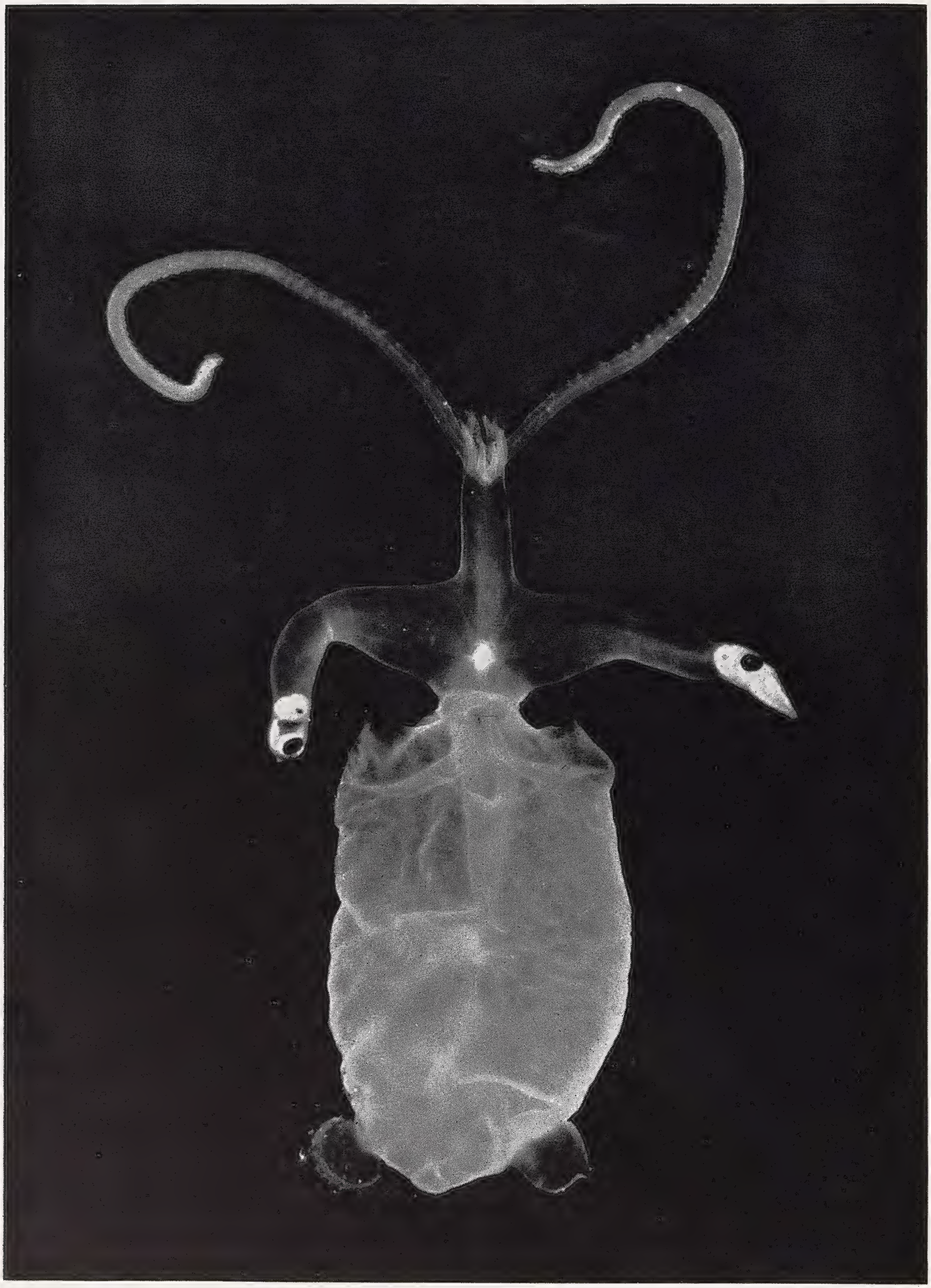
Now that we have pictured the red-coated army of dye particles invading the bones, we can imagine a more invisible cohort in the colorless clearing bath. This faction attracts and unites with various fluids of the body, such as water, leaving the specimens as clear as crystal.

Before us on the laboratory table is an array of transparent, ghost-like forms of what, a short time before, were strange black beings from a mile down. The large-headed gulper eel is revealed in its true, almost headless form. Suspended from its diminutive skull is the cavernous, sack-like mouth. Behind this is a slender, whip-like tail serving to propel this animated deep-sea trap toward its food. No ribs are attached to the simple scarlet backbone which extends from the skull to the very tip of the tail.

An amazing contrast to this slender eel is a tiny sphere of a fish—a deep-sea puffer, which in life, reveals no outward hint of hidden secrets. But in transparent form we see that over three-fourths of its body is an enormously developed head. The vertebral column is almost wanting. The dye emphasizes its weakness and disuse and simultaneously indicates a compensation. Pointing outward from the thick covering of skin which envelopes the whole body are hundreds of lance-like bony spines—a warning to preying enemies.

The rare deep-sea fish *Opistoproctus* with upwardly directed light-seeking eyes, has never been given full credit for its true figure because of its scarceness in deep-sea hauls. Only a single representative of this species reported to have his skeleton recorded during the six months of our trawling. Unlike the three specimens collected by other expeditions this one arrived from a depth of six hundred fathoms in perfect condition. After dyeing and clearing, the tail bones are seen to be symmetrically arranged, which is quite contrary to former observations on uncleared, damaged specimens.

This fish is designed like a sea-sled with a solid flat bottom skid. Together with the pointed profile of the snout this skid forms a V-shaped hollow which has been described as the mouth. While this would seem perfectly adapted for sliding over irregular submarine surfaces, the fish actually lives half a mile above the floor of the ocean, leaving us without any explanation for the complicated bony undergear. Study of the actual bones shows that the real mouth is very small and high up in the head, far above the indenture which, in profile, resembles the oral opening. In this and in a hundred other ways the revealed skeletons tell us invaluable things about the habits of all these deep-sea fish, which we may never be able to study in their icy submarine haunts.



A remarkable, luminous, abysmal squid with only two elongated arms, and with the eyes on the ends of long tentacles.

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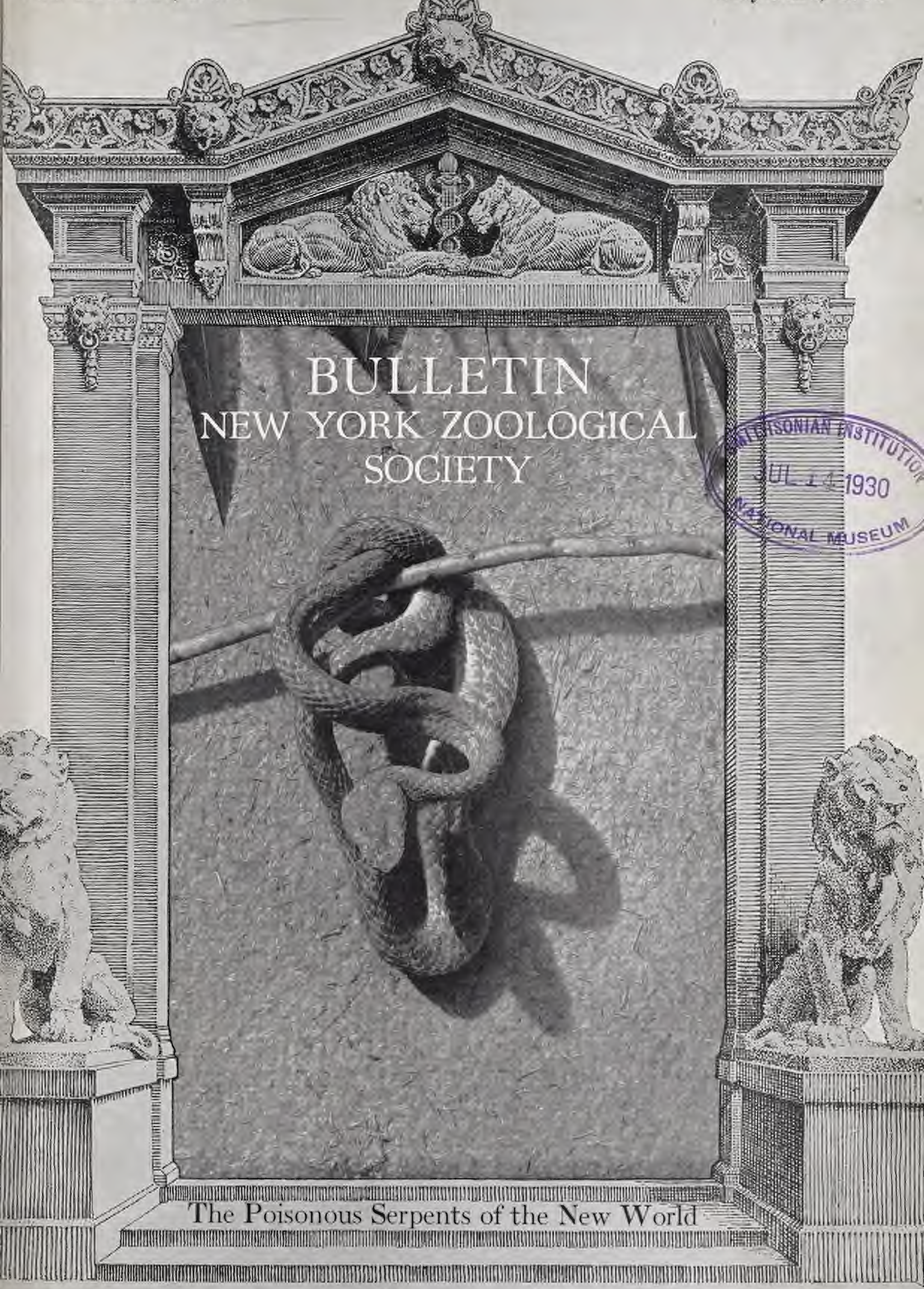

BULLETIN
NEW YORK ZOOLOGICAL SOCIETY

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JUL 14 1930
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BULLETIN

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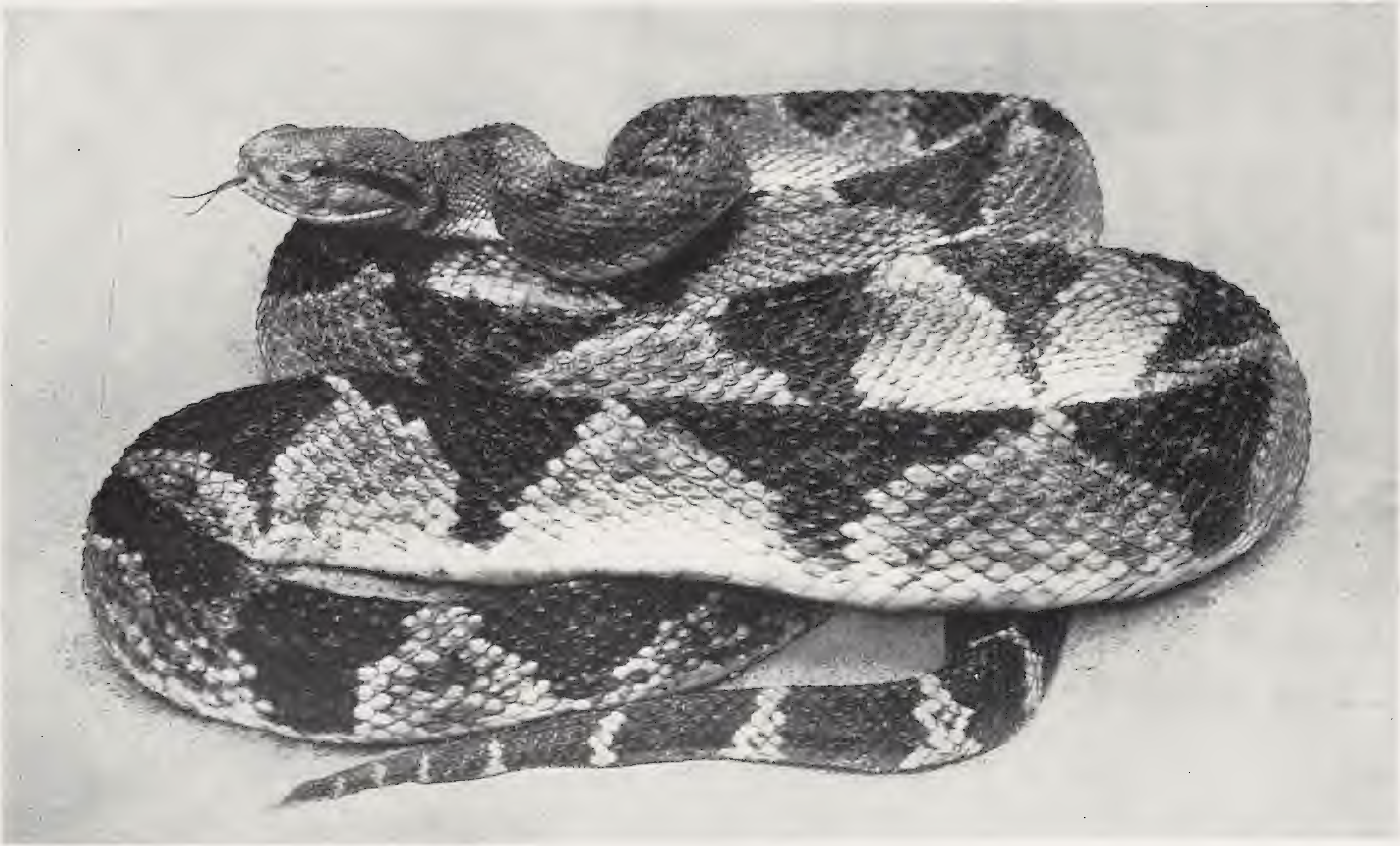

Fig. 1. The Bushmaster; Surucucu, *Lachesis muta.* Attaining a length of twelve feet, this dramatic species of the American tropics may justly be rated as the king of the world's viperine serpents. Drop for drop its venom is not so deadly as that of some other New World species, but excessive fang length and the amount of venom injected at a bite, render it the most formidable of the New World poisonous reptiles. It ranges from southern Central America throughout equatorial South America.

BULLETIN
NEW YORK ZOOLOGICAL SOCIETY
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The Poisonous Serpents of the New World

A Comparative Review

Raymond L. Ditmars, Lit.D.
Curator of Mammals and Reptiles, Zoological Park.

Illustrated from photographs made in the Zoological Park by the Author and Elwin R. Sanborn. Also from photographs made in the field as indicated under the plates.

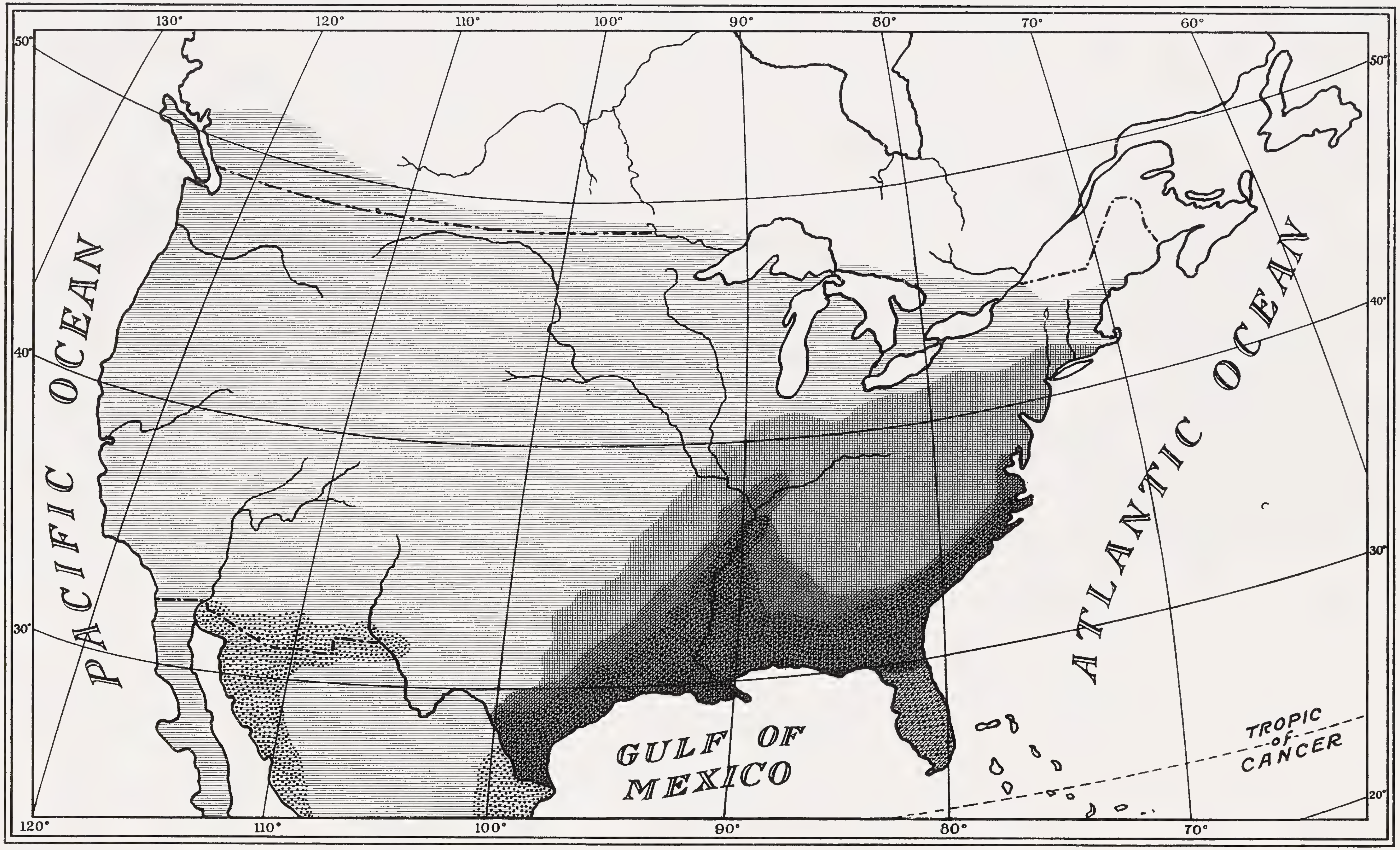
THIS work has been prepared after requests for a readable account of the poisonous serpents of North and South America and the adjacent areas. The plan has been to bring them together with generally complete illustrative detail for comparison and identification. Queries from various latitudes have guided the author in presenting the text as a zoogeographical account. This produces a practicable summary for persons going into unfamiliar country, to planters or others engaged in permanent work in broadly scattered areas, and to students generally. The illustrations are arranged in the continuity of zoological classification.

The author has made personal investigations over a wide area. These have been recorded from coast to coast in North America, including the southwestern deserts; in Mexico, Guatemala, Honduras, Costa Rica and Panama; and in Brazil.

The poisonous snakes of the New World, comprising some of the most deadly known species, and some of great abundance, have not been considered collectively in terms that may be broadly understood. Three important conditions are to be noted at the beginning:

The North American poisonous species are quite different in their make-up from the tropical types. Their venoms are different and require treatment by specific grades of serum to produce the most efficacious results. With the exception of the eastern copperhead, the southeastern water moccasin and two small coral snakes in the southerly latitudes, the greater area of North America contains but one other type of poisonous serpent—the rattlesnake. There is, however, a considerable number of species of rattlesnakes. Approximately a dozen distinct kinds of these characteristic serpents occur in various parts of the United States. There is great variety in size, pattern and coloration. They inhabit a variety of country, some being characteristic in frequenting deserts, others plains, swampy areas or mountains.

South of the northerly and arid area of Mexico, the status of the rattlesnake group changes in the disappearance of species and through the Central American countries and over the entire South American continent, there is but a single distinct species. This has a symmetrical, rhomb-like pattern. The United States, therefore, is the headquarters of the rattlesnakes, with the greater number of the



Distribution of the four "types" of poisonous snakes of North America. The horizontal shading (also underlying all others) shows the area inhabited by rattlesnakes. The vertical lines indicate *habitat* of the copperhead snake (they underlie the dotted area to the base of Florida). The oblique lines represent the distribution of the true water moccasin (and underlie all portions of the southeastern dotted area). The dotted areas approximately show the occurrence of coral snakes.

species forming a radiating group in the southwesterly portion.

The second point relates to the appearance, in Mexico, of the characteristic type of poisonous snake of the New World tropics. This is the so-called lance-head type of pit viper of the genus *Bothrops*. All of the tropical American vipers, with the exception of the bushmaster and a water moccasin, have been assigned to this genus, although the slender-bodied, tree-climbing species with a prehensile tail appear to warrant recognition within a distinct genus. We may take the fer-de-lance as a representative species of *Bothrops*. The name fer-de-lance (relating to the shape of the head—like an iron lance) is a Creole-French term coming from the southerly West Indies. In Central America it is commonly called the barba amarilla (yellow-beard) and in Brazil the jararaca—the latter word relating to an arrow and referring to the shape of the head.

It is the most abundant and widely distributed poisonous serpent of the New World, and represents the characteristic type most broadly developed in the American tropics. All told, approximately twenty-four species of *Bothrops* are scientifically listed. The genus is to a certain extent monotonous in form and pattern of its members. Their venom is largely composed of a powerful haematoxin, which destroys the red cells of the blood and breaks down the walls of the carrying vessels. Rather dominating in its difference is the great bushmaster, extending from Nicaragua and Costa Rica well through Brazil. It is the giant among vipers, attaining a length of twelve feet. Its single species is assigned to a separate genus, *Lachesis*. A number of species of brightly colored coral snakes (*Micrurus*) inhabit the tropical area.

The third point of summary relates to the absence of poisonous serpents in all of the large islands of the West Indies. No dangerous reptiles occur in Cuba, Jamaica, Hayti or Porto Rico, nor anywhere in the West Indies except in the Windward Islands, where the fer-de-lance occurs in St. Lucia, Martinique and Tobago—and Trinidad, lying close to the mainland. The coral snake also occurs on these islands, including St. Vincent. This absence of poisonous reptiles among all the large islands is all the more remarkable owing to the proximity of an infested Central American mainland, the luxuriance of flora of the islands, and climate conducive to reptile development. The islands are fairly well populated with harmless reptiles. This point is graphically illustrated by the map of the Central American and West Indian areas. Particular detail has been applied to the Central American area as queries about the reptile life in these near-by American tropics have indicated the need of descriptive details.

The North American Species

Practically every portion of the United States is inhabited by poisonous serpents—although we might accord to a few states in the northeastern corner of this far-flung area the reputation of being nearly or quite free of them. These are the states of Maine, New Hampshire and Vermont. There are occasional reports of rattlers in the southerly portion of Vermont. The northerly states to the westward are liberally inhabited by rattlesnakes which extend their habitat well into Canada. This condition extends westward to the Pacific Coast. Our southeastern states, warmed by their contact with the Gulf Stream, with thick tangles of river swamps and humid coastal areas, harbour large numbers of poisonous serpents. Texas, Arizona and New Mexico are very liberally supplied with rattlers. The Pacific states also have large numbers of rattlesnakes, while the interior states show "spotty" occurrence, abundant in some areas, moderately so in others. The writer doubts, however, if there are any portions much more abundantly supplied with venomous snakes than some areas of Massachusetts, Connecticut, New York, New Jersey and Pennsylvania, where the timber rattlesnake and copperhead infest the mountain ledges.

The species of rattlesnakes vary in size from several that are not larger than the average striped snake to the huge and formidable diamond-back, which attains a length of over eight feet and a circumference of about twelve inches. Throughout the northeastern portion of the United States there is but a single abundant species—the banded or timber rattlesnake, although in western New York a small rattler—the massasauga—is occasionally found and becomes rather common in the eastern central states. The timber rattlesnake gives way on the eastern plains to a species of wide distribution—the prairie rattlesnake, which, in its variation or races, extends westward throughout the Pacific region, and into the Southwest. Going south, in the eastern United States, there is another rattler from about the central portion of North Carolina. This is the diminutive pygmy rattlesnake. Slightly farther south is the range of the big southern diamond-back, which attains the greatest length of any rattlesnake, and is one of the most formidable vipers of the world. The Mississippi Valley forms the western boundary of this deadly species, its place being taken in Texas, thence westward to eastern California, by the big diamond-back of the arid regions—a close second in size, attaining a length of seven feet or more, with the same proportionately heavy body. Going westward into its habitat, we enter the headquarters of the rattlesnakes in the Southwest.

At least four species of rattlesnakes are found in Texas, but the southwestern states have three times that number of distinct kinds. Most of them are confined to the desert areas.

In this distribution of poisonous serpents in North America, two species of moccasins must be considered—the water moccasin and the copperhead snake (highland moccasin, pilot snake or chunkhead). These belong, as do the rattlers, to the family of pit vipers having a deep pit on each side of the head between the eye and the nostril. The water moccasin is common in the swamps and sluggish waterways of South Carolina, Georgia, Florida, Alabama and Louisiana—also portions of adjoining states. The distribution of the copperhead is extensive. It ranges from southern Massachusetts to northern Florida, westward to Oklahoma and Texas in the south, and to Illinois in the northerly portion. It will thus be understood that over the actual West, the only type of poisonous serpent is the rattlesnake (except for a coral snake in the Mexican boundary region).

In the southeastern states, thence along the United States-Mexican boundary, there are two small poisonous serpents of brilliant coloration known as coral snakes. The common coral snake or harlequin snake occurs from southern North Carolina throughout Florida and westward to Texas.

Coral Snakes: The species of *Micrurus* (formerly *Elaps*) are different in form, coloration and habits from all of the other New World poisonous serpents. They are slender, with smooth and glossy scales. The North American species are usually well under three feet in length. The head is not distinct from the neck. Coloration, throughout the genus, is brilliant and in the form of rings of red, yellow and black. These serpents are of burrowing habits, although occasionally found prowling. They are degenerate, New World representatives of the *Elapidae,* the family to which the cobras, krait, mamba and other extremely dangerous Indian, African and Australian types belong.

The bites of coral snakes are very dangerous, the venom being of neurotoxic action, quite different from that of the rattlesnakes and moccasins.

The Coral Snake; Harlequin Snake; Bead Snake, *Micrurus fulvius* (Linné), (Figures 5 and 8), lives much of the time in the ground, though it is sometimes seen in the fields during spring plowing. There are wide rings of crimson and black, the latter narrowly bordered with yellow. Several small harmless serpents "imitate" the coloration to a remarkable degree. Close inspection, however, will show that with the non-venomous species, there are pairs of black rings bordering a yellow one, the reverse of the poisonous type.

The coral snake feeds largely upon the young of other serpents and upon lizards. It does not strike. If stepped on or actually touched, it will turn and deliberately bite, retaining its hold. Accidents are infrequent, but fatal cases from its bite have been reported. Its range is from South Carolina and Mississippi to Florida, the Gulf States, thence southward into Mexico and Central America.

The Sonoran Coral Snake, *Micrurus euryxanthus* (Kennicott), (Figure 9), is similar to the eastern species, but the black rings are proportionately narrower and the yellow marginal rings much wider. Its range is indicated as southern New Mexico, Arizona and northern Mexico.

The Pit Vipers: The dominating poisonous serpents of North America belong to the *Crotalidae,* a cosmopolitan family. The members are distinguished by a deep pit between the eye and the nostril. The eyes have elliptical pupils, and in North America, at least, these and the head pits serve as distinguishing points for identification, as practically all of the harmless snakes have a round pupil.

The pit vipers are provided with a pair of long, erectile, poison-conducting fangs in the upper jaw (Figures 12 and 13). These fangs are hollow, and in structure like a hypodermic needle. They are attached to movable bones and fold back against the roof of the mouth when the jaws are closed. A membranous sheathing covers the fangs, except when they actually penetrate an object in the act of biting (Figure 14). Pit vipers coil and strike in defense, the blow terminating in a strike aided by an instantaneous bite. At the instant of biting, the muscle over each temporal poison gland is contracted, forcing venom forward and out of the hollow fangs. The dual wounds produced are no more or less than hypodermic injections. The strike and bite are so simultaneous that the reptile appears to instantly return to the former defensive position after the out-thrust of the head from a lateral, S-shaped loop of the neck.

Three genera are represented in North America: *Agkistrodon* (the moccasins); *Sistrurus* (the pygmy rattlesnakes); and *Crotalus* (the typical rattlesnakes).

The Copperhead Snake; Chunkhead; Pilot; Rattlesnake Pilot; Highland Moccasin, *Agkistrodon mokasen* Beauvois, (Figures 15 and 16). The body hue is pale brown, pinkish or light reddish brown, with a series of large blotches on the sides, somewhat like inverted "Y"s. These are usually of a rich, chestnut brown. When looked at from above, a number of the markings will be seen to unite across the back, producing a continuous pattern across the body, the central portion being narrow and broadening on each side, giving the outline of an hour-glass. Numerous specimens from Texas have very wide —consequently fewer—bands, most of them encircling the back and not narrowed at the top, as with eastern specimens.

The range is from central Massachusetts to northern Florida (not including the peninsula), westward to Illinois, thence southwest through Missouri and into Oklahoma and Texas.

The Water Moccasin; Cotton-mouth Snake, *Agkistrodon piscivorus* (Lacépéde), (Figure 17). The term "cotton-mouth" comes from the habit of opening the mouth in threatening fashion, the mouth parts being whitish.

This is an aquatic serpent, living along streams, lakes, or in swamps. It is particularly abundant along the old abandoned rice ditches of the southern states, and is a much larger and more dangerous reptile than the copperhead, also considerably more pugnacious. It attains a length of six feet, but the average is three to four feet. The colors are dull brown or olive, crossed with darker, usually obscure bands. Young specimens are brightly marked with transverse blotches on a reddish ground.

Distribution is from Virginia, throughout the state of Florida and westerly along the Gulf States into eastern Texas. Inland there is a northerly extension up the Mississippi Valley to southern Illinois, Missouri and western Kentucky.

The Massasauga, *Sistrurus catenatus* (Rafinesque), (Figure 41). A small, brownish or grayish rattlesnake, with chesnut-brown blotches on the back, and a similar row on each side. The species of *Sistrurus,* may be distinguished from members of the typical rattlesnake genus *Crotalus,* by the symmetrical plates on the top of the head.

The Massasauga is from two to three feet long. Occurrence is from western New York, through Ohio to Nebraska, northward into Michigan and Ontario, and southward to Kansas. It often frequents swampy places.

Edward's Massasauga, *Sistrurus catenatus edwardsii* (Baird & Girard) is a southerly subspecies, the blotches proportionately much smaller.

The Pygmy Rattlesnake; "Ground" Rattler, *Sistrurus miliarius* (Linné), (Figure 40) is smaller, seldom more than sixteen to twenty inches long, the rattle so minute as to be scarcely heard. It is common from southern North Carolina throughout Florida and westward to Oklahoma and Texas. The body hue is grayish, with a series of rather widely separated, rounded blotches, and a reddish band along the back, this more vivid on the anterior portion.

The Banded Rattlesnake; Timber Rattlesnake; Canebrake Rattlesnake, *Crotalus horridus* Linné, (Figures 57 and 58), has the most extensive distribution of any poisonous serpent in North America with the exception of the prairie rattlesnake and its various races. It occurs from southern Maine to the easterly portion of the Great Plains, southward to northern Florida, and westerly into Arkansas and eastern Texas.

While preferring mountainous areas, particularly ledgy places, this serpent differs from some other rattlesnakes in exhibiting extreme versatility of living conditions. In New Jersey it inhabits not only the mountainous portions, but is found in the flat central portion, where it hibernates under layers of damp sphagnum moss. In the great swamps or canebrakes of the southeast and lower Mississippi, it grows to a larger size and assumes unique coloration —a pinkish body hue, sooty black markings and narrow dorsal stripe of rusty red. This variation appears to indicate a distinct race, and may ultimately warrant a subspecific name. It is commonly known as the "canebrake" rattlesnake.

The typical coloration is yellow or tan, with wavy crossbands of dark brown or black. Many specimens are well suffused with black, and some are almost entirely black.

The species is common in hilly portions of Massachusetts, New York, Connecticut, New Jersey, Pennsylvania, the Virginias, the Carolinas, Kentucky and Tennessee—in fact, showing the greatest abundance in rocky areas on mountains, where it congregates at specific crevices in ledges every year to hibernate. Its numbers are not being reduced. It has actually become more abundant during the past twenty-five years over portions of the east, particularly in New York, New Jersey and Pennsylvania.

The average length is about four feet in the north, though the writer has measured six foot specimens. The canebrake rattlers of the south attain a length of eight feet, with proportionately smaller head and stouter body than northern specimens.

There is less danger from this snake than from others of its genus, as it does not readily strike unless molested. Mountain specimens prefer to lie motionless, half tucked under shelving rocks, in the hope of being passed without detection, or, if noting danger, to be able to glide into a sheltering crevice. Disturbed in the open, the species usually sounds the rattle, while the intruder is still some distance away.

The Diamond-back Rattlesnake, *Crotalus adamanteus,* Beauvois, (Figure 45). This is the largest and most dangerous of the poisonous serpents of North America. Frequent specimens are six feet in length, and it attains a length of over eight feet, with proportionately heavy body. A six foot specimen will weigh about twelve pounds, have a head nearly three inches in width, and fangs three quarters of an inch long. The great amount of venom injected by such a creature may be surmised.

This powerful reptile inhabits the coastal areas of the Southeast, showing a preference for prowling through scrub palmetto or low brush. It is frequently noted along the wilder sea beaches in Florida where it lurks in the extensive stretches of tangled brush but a short distance from the line of the higher tide wash. The writer has also observed it in the sand hammocks, where the gopher tortoise digs its burrows. It is not a swamp species, although it may frequent woods close to water and does not hesitate to swim across small bodies of water. In the coastal strips it crosses fair-sized tide pools and has been noted several miles from shore, where it has been accidentally carried by the currents. It is also found along the Keys.

Pattern is bold and constant, in the form of a chain of symmetrical rhombs. When adult it feeds largely upon rabbits.

The Western Diamond Rattlesnake, *Crotalus atrox* Baird & Girard, (Figure 46), may be rated as the second most formidable serpent of North America, as to bulk and amount of poison expended at a bite, but it holds first rank in the number of fatalities in listing snake-bites, owing to its great abundance over a wide area.

Both this and the southeastern diamond-back are particularly dangerous in their tendency to quickly strike when accidentally approached. They are given to prowling over ground with little shelter. When disturbed their habit is to throw the body into a coil, sound the warning rattle and deliver a blow. If suddenly surprised, the warning and stroke may be almost simultaneous.

Adult examples of the western diamond-back commonly attain a length of six feet, and there are occasional larger specimens, but the average run is smaller than the big southeastern species. The pattern shows a chain of symmetrical rhombs on a grayish ground. Examples from the sterile areas are pallid, with obscure rhombs, and vary from gray to yellow or pinkish.

The range embraces Texas and extends westward through New Mexico, Arizona and into California. Occurrence also covers a wide area in northern Mexico, with Lower California included. As to its extreme westerly occurrence, Klauber states: "The Colorado Desert in California; likewise northeastern Lower California and Tiburan Island."

The western diamond rattlesnake has several close allies, as follows:

The Mojave Diamond Rattlesnake, *Crotalus scutulatus* (Kennicott), (Figure 48), recognized by the enlarged scales on the top of the head. It ranges from the arid Southwest into northern Mexico.

The San Lucan Diamond Rattlesnake, *Crotalus lucasensis* Van Denburgh, which is restricted to southern Lower California.

The Tortuga Island Diamond Rattlesnake, *Crotalus tortugensis* Van Denburgh and Slevin, of Tortuga Island, Lower California.

The Cedros Island Diamond Rattlesnake, *Crotalus exsul* Garman, which is reddish and apparently recorded only from Cedros Island, Lower California.

The Red Diamond Rattlesnake, *Crotalus ruber** (Cope), (Figure 47). This is distinctly reddish (usually of brick-like hue) with rather obscure and narrow rhomblike markings. It is a quite common and rather large species of limited distribution. The average adult is from four to five feet long, but it occasionally attains a length of six feet. Klauber defines its range as follows: "The narrow belt in California and Lower California west of the desert to the coast, from the north line of Riverside County in California to north central Lower California, but excluding the coastal plains of Los Angeles and Orange Counties. It occurs also on Cerros and certain Gulf of California Islands."

This powerful rattlesnake is at times curiously gentle, showing little excitement if disturbed, and no inclination to strike. It is sometimes difficult to induce it to rattle. Again, found wandering in the open, with no sheltering brush or crevices in which to retreat, it will quickly coil and assume a threatening attitude as if realizing this is the only hope of survival. It is a calm and quiet captive, seldom sounding the rattle.

The Black-tailed Rattlesnake, *Crotalus molossus* Baird & Girard, (Figure 44), indicates relationship to the tropical rattlesnake of wide occurrence to the south, by its more than moderately high keeled scales, and its markings. It is a handsome reptile, with dark rhomboidal blotches edged with yellow and enclosing lighter patches. The tail is usually black. The general body hue is rich yellow—sometimes darker.

It is fairly large, although restricted in size in some portions of its range, which in the United States is along the boundary region from Texas to Arizona. Southward in Mexico it appears to overlap the northern range of the tropical rattlesnake, *Crotalus terrificus*.

The western rattlesnakes have recently received detailed studies which have resulted in some radical changes of long-standing names. These studies have been rendered possible from large series of specimens accumulating in the scientific institutions, affording extensive opportunities for comparison. The most detailed investigations have been conducted by Amaral and Klauber. The former presented a provisional key to the rattlesnakes in a bulletin of the Antivenin Institute of America, in 1929. More recently, Klauber prepared a lengthy paper in the Transactions of the Zoological Society of San Diego and has given the writer advance details of very recent findings. These studies are listed in the bibliography at the end of this work.

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* Formerly *exsul*, which name is now applied to the Cedros Island species.

The more important findings relate to the relationship of the Pacific rattlesnake, long considered a valid species, to the prairie rattlesnake and the definite races or subspecies of the latter in the Southwest. Also the status of the tiger rattlesnake, showing it to be truly an Arizona and north Mexican species, and the so-called tiger rattlesnake of Nevada and desert California to actually represent southwesterly races of the prairie rattlesnake. Mitchell's rattlesnake (the white or pallid rattlesnake), long listed as a valid species, also becomes a subspecies of the prairie rattlesnake.

The Prairie Rattlesnake, *Crotalus confluentus confluentus* Say, (Figure 49), and its races or subspecies has the widest range of any North American species of its genus. Its extension into Canada indicates that it ranges farther north than any other rattlesnake. The distribution of the typical form covers the Great Plains from the longitude of eastern Nebraska to the Rocky Mountains, extending southward to central Texas along the easterly range, and to the Mexican border to the westward. Extension northward is into Canada, at least to the fiftieth parallel. This snake appears to be abundant in the vicinity of Medicine Hat.

Usual coloration is yellowish to darker brown, with a symmetrical row of rounded and separated blotches on the back, these narrowly bordered with yellow or white, and a distinct V-shaped marking of light color on the large shield above each eye.

Despite its poisonous nature, the prairie rattlesnake is undoubtedly of considerable economic importance over a great area, owing to it being one of the natural enemies of destructive rodents.

The Pacific Rattlesnake, *Crotalus confluentus oreganus* (Holbrook), (Figures 50 and 51). This is the common and only rattlesnake of the Pacific region north of southern California, and represents a westerly race of the prairie rattlesnake, from which it differs in tendency toward darker markings, even to suffusion of black, and the edges of the blotches fusing in a rhomb-like chain. In southern California, its range overlaps most of the other California species except *Crotalus atrox,* in the area of the Colorado desert. It occurs over varied country, embracing the mountains up to altitudes of eight thousand feet, the sea coast levels, inland plains, and desert areas. It is as much at home on the sterile slopes of desert mountains as in regions of heavy timber. The range is from British Columbia southward through Washington, Oregon and California, and into Lower California. It also occurs on Santa Catalina and Los Coronados Islands. Eastward the habitat extends into Idaho, Nevada, Utah and Arizona, overlapping the typical form.

While occasionally attaining a length of five feet, the average size is between three and four feet. There is a variation in pattern and hues, ranging from brown to grayish or greenish, with large dorsal blotches edged with a paler hue, these lighter margins in contact, to blackish specimens with no markings but the paler edges, indicating the dorsal blotches. Such specimens are sometimes called "diamond-backs."

In the northern portion of the range, this snake congregates in the fall at specific crevices in rocky ledges, in preparation to hibernate. Large numbers annually return to these places, which are the so-called snake dens. Such habits are similar to those of the prairie rattlesnake, along eroded river banks, and the timber rattlesnake on mountain ledges in the east.

The following additional subspecies of *confluentus* have been recently named:

The Great Basin Rattlesnake, *Crotalus confluentus lutosus* Klauber, (Figure 52). Found in the Plateau Region from the Rockies to the Sierras, including Utah, Nevada, northern California east of the Sierras, southeastern Oregon and southern Idaho.

The Midget Faded Rattlesnake, *Crotalus confluentus concolor* (Woodbury). Recorded from Utah and Colorado.

The Grand Canyon Rattlesnake, *Crotalus confluentus abyssus* Klauber, (Figure 53). A form observed only in the Grand Canyon of the Colorado, in Arizona. Klauber states, "In the Grand Canyon occurs a peculiar phase of *Crotalus confluentus,* distinguished by its vermilion or salmon coloration and an almost complete absence of markings in the adult."

The Panamint Rattlesnake, *Crotalus confluentus stephensi* Klauber, (Figure 54), has been thus far recorded from northwestern Esmeralda County, Nevada, and Round Valley, Mono County, California, southeasterly to Clark County, Nevada, and northern San Bernardino County, California. It appears that this snake has formerly been confused with Mitchell's rattlesnake—the white or bleached rattlesnake—(the subspecies following), but the sponsor for its subspecific name describes a difference in the arrangement of the head plates.* It has also been confused with the tiger rattlesnake, which appears to be confined to Arizona and northern Mexico. It is a rather pallid, desert form.†

Mitchell's Rattlesnake; White Rattlesnake; Bleached Rattlesnake, *Crotalus confluentus mitchellii* (Cope), (Figure 55), is a pallid variety, with obscure, transverse markings. Its length is from four to five feet. The keels of the body scales are quite high and rough, and there may be an indicated relationship here with the rattlers of Mexico, which would be diverse to the taxonomic arrangement. Some examples are almost white. The usual hues are yellowish, gray, or even pinkish. Desert mountain slopes, among rocks, scattered cacti and thorny bushes, are the usual lurking places. A coiled specimen resembles a big tuft of faded cotton among the rocks.

Distribution is from central Arizona to the base of the foothills on the western slope of the Coast Range in California, from northern Los Angeles County southward throughout the entire peninsula of Lower California; also on Santa Margarita and other islands in the Gulf of California.

The Tiger Rattlesnake, *Crotalus tigris* Kennicott, (Figure 56), receives its name from the tawny body hue, with darker markings of ring-like pattern. It inhabits the deserts of Arizona and northern Mexico, preferring the higher slopes, among the rocks.

The Lower California Rattlesnake, *Crotalus enyo* (Cope), occurs in Lower California. The anterior markings are transversely rhomb-like, becoming narrower, or band-like on the posterior portion. It appears to be confined to the southerly portion of Lower California.

The Horned Rattlesnake; "Sidewinder," *Crotalus cerastes* Hollowell, (Figures 61 and 62). A strictly desert species of small size and pallid hues, occurring in southern California, Nevada, Arizona and portions of southwestern Utah. The large scale above each eye is developed into an upright horn. Living on dry and yielding sand, this snake progresses by throwing lateral loops of the body forward, causing it to move off at an oblique angle to the direction in which the head is pointing, and with such a degree of agility as to appear grotesque and warrant the name "Sidewinder."

The Spotted Rattlesnake,* *Crotalus triseriatus* (Wagler), (Figure 59). A small grayish species, with rows of spots extending lengthwise, but fusing into cross bands on the tail. It is reported as rare and occurs in the mountains of southern Arizona and northern Mexico.

The Green Rattlesnake, *Crotalus lepidus* (Kennicott), (Figure 60). Another small species, seldom exceeding twenty-four inches and readily distinguished by its greenish or greenish-gray hue, marked by widely separated and narrow rings of black. Always regarded as of rare occurrence, although the range extends along the region of the Mexican boundary, from Eagle Pass on the Rio Grande, westward through New Mexico and Arizona. Its distribution into Mexico is not definitely known.

Willard's Rattlesnake, *Crotalus willardi* Meek. Apparently the smallest rattlesnake, and of rare occurrence. The length appears to be not more than fifteen inches. It is recorded from Arizona and northern Mexico. Two parallel white stripes, one on the lip and the other extending from the snout thence beneath the eye and to the lower and rear portion of the jaw, are characteristic.

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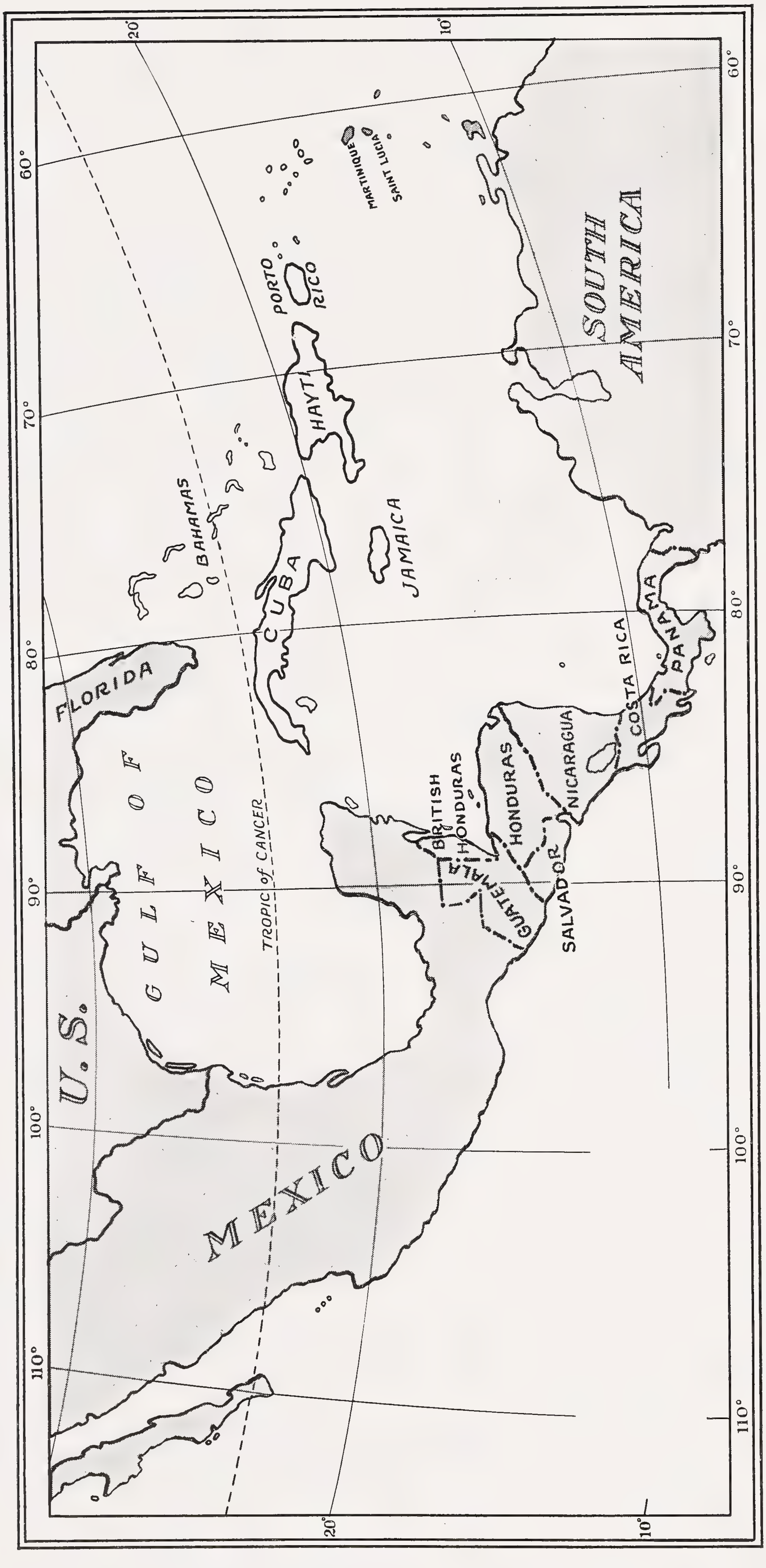
* "From *mitchellii* it differs in having the rostral generally in contact with the prenasal." (Klauber).

† Full technical definition of this and other subspecies of *Crotalus confluentus* are presented in the Transactions of the San Diego Society of Natural History, Vol. VI, No. 3, pp. 95-144, plates 9-12, with map.

* Formerly designated as *pricei.*



This map illustrates the absence of poisonous serpents in the West Indies. The shaded portions (the mainland and a few islands on the extreme right) show the occurrence of venomous snakes. The unshaded portions contain no dangerous reptiles. Nestled as they are within the curving shores of infested mainlands, it appears remarkable that Cuba, Jamaica, Hayti and Porto Rico, with their luxuriance of tropical flora, have never furnished records of poisonous reptiles.

The Mexican and Central American Species

A radical change in the species of poisonous serpents take place south of the arid portion of Mexico. The rattlesnakes abruptly give way and serpents of the genus *Bothrops,* typical of the American tropics, appear. The reptilian fauna of the Central American countries and South America is quite similar, although a number of species occurring in the latter are characteristic to the more southerly countries, and the great bushmaster is found only in the southerly portion of the Central American area, whence it ranges southward through the South American tropics. The prevailing and most widely distributed poisonous species are the rattlesnake now restricted to a single species and on high ground, and the fer-de-lance or barba amarilla, *Bothrops atrox,* in the low, coastal areas. Coral snakes are common in the humid forests. A poisonous sea snake occurs in the bays and off the western coasts of Central America.

Marine Serpents: The curious members of the *Hydrophidae* or sea snakes may be recognized by the vertically compressed or paddle-like tail. There are many species which abound in the Indian Ocean and the western tropical Pacific. A single kind, however, occurs in waters of the New World—off the west coast of Mexico, Central America and northern South America. All of the marine serpents are very poisonous and appear to be highly specialized allies of the Elapine group.

The Yellow-bellied Sea Snake, *Pelamydrus platurus* (Linné), may be recognized by its rather eel-like form, with quite long head, the body compressed and covered above and beneath with small, round scales. Coloration is vivid and unusual. The upper half of the body is black or dark brown, the lower half yellow, demarkation being very apparent while the creature is swimming, particularly if seen from the side. Length is seldom over three feet. It is extensively distributed through the tropical Pacific, and into the Indian Ocean, and often observed in the Bay of Panama and off Punta Arena, Costa Rica, where it may be watched for from steamers clearing the Panama Canal for west coast ports, north or south. It also occurs in the lower Gulf of California.

The Coral Snakes: The genus *Micrurus (Elaps)*, despite the brilliant coloration of its members, is at best a monotonous one, and to list the Central American species would produce a repetition not particularly helpful. A typical Central American species has been selected for photographic illustration together with a series of drawings to show the varying widths of the red bands and the ratio of black to yellow rings among these serpents. The coral snakes of the tropics attain a considerably larger size than those occurring in the United States. Some examples attain a length of nearly four feet, and while they seldom strike, will immediately bite if stepped on. An unfortunate victim in bare feet may find the reptile imbedding its short fangs and retaining its hold. Such bites of the larger species are usually fatal.

In Mexico the common name for these reptiles is "coralilla" and in Central America "gargantilla," the latter meaning a necklace and relating to the similarity of the patterns of these serpents to beads strung in color designs. At least eight species appear to occur in Mexican and Central American areas, among these being *Micrurus fulvius,* ranging southward from the United States—but with proportionately wider red rings, *M. mipartitus* and *M. nigrocinctus.* The latter is commonly seen from Guatemala to Panama and is shown in a photograph from life—(Figure 7).

The Viperine Snakes: The Tropical Water Moccasin; "Cantil," *Agkistrodon bilineatus* Gunther, (Figure 18). This water moccasin is far more dangerous than the species of the North. It is savage, extremely quick, and inclined to instantly strike. Its poison has a higher toxicity than its northern ally.

The large, symmetrical shields on the top of the head immediately distinguish it as a typical moccasin, and offer a point of differentiation from the vipers of the genus *Bothrops.* It is boldly marked, in decorative pattern, as if embellished with touches of white enamel, and seems to be a smaller species than that of the United States. The writer has noted no specimen over four feet in length. This moccasin should be looked for in swamps and in the marginal vegetation of streams.

Records indicate that it is confined to southern Mexico and the northerly part of the Central American tropics. Listings record it from Tres Marias Island, Colima, Guadalajara, Tehuantepec and Yucatan, also the Pacific coast of Guatemala. The writer heard of it near Belize in British Honduras, but in a careful search of swamps and waterways in the Republic of Honduras failed to find it, nor had Douglas March in his field work found it that far south.

The Palm Vipers: This is a group of quite slender, rather small species—seldom over a yard in length. They are arboreal, have a particularly wide head and all are characterized by a prehensile tail, which as a rule is kept promiscuously twisted about some projection. Approximately six species are listed as occurring in the southern Mexican and Central American area.

Schlegel's Palm Viper; the Horned Palm Viper; the Eyelash Viper; "Bocaraca"; "Toboba de pestana," *Bothrops schlegelii* (Berthold), (Figure 21), is distinct by the development of several small scales between the eye and the large plate above it. Two or three of these scales are directed upward to form spiny horns. There are two color phases. One is greenish or olive, speckled with black and red; the other, equally common, is yellow, often of pale lemon hue, speckled with black. The yellow examples are known as "Orapel."

Prospectors should be wary about going through thick, bushy places. These arboreal vipers are not readily detected, as they blend with surroundings. Under such conditions men have been bitten on the hands and face. A trail gang, cutting through the jungle in the Republic of Honduras had such accidents, several of them terminating fatally. While these snakes are small, the proportionately large head and long fangs, together with a highly toxic venom, render them very dangerous. Range of the horned or eyelash viper includes Guatemala, south through Central America and well into South America.

The Mexican Palm Viper, *Bothrops undulatus* (Jan), also has a horn-like development over the eye, but this is produced by a single upturned scale. This snake is olive or brown, with large, rhomb-like spots, sometimes connected to form a zig-zag band. Recorded from Mexico —Omilteme in Guerrero, Orizaba, Vera Cruz, Actopam and Oaxaca. It probably ranges into Guatemala.

The Green Palm Viper, *Bothrops bicolor* Bocourt, is uniform leaf green above and yellow beneath and recorded from western Guatemala.

The Yellow-lined Palm Viper, *Bothrops lateralis* (Peters), is green above and beneath, with a yellow line along each side. Some specimens have yellow and dark cross bands on the back. It is found in Costa Rica.

The Black Spotted Palm Viper, *Bothrops nigroviridis* (Peters), illustrates how observation extends the knowledge of a species. This snake was for a long time listed as occurring in Panama and Costa Rica. Through the field studies of Douglas March, in charge of the Serpentarium at Tela, Honduras, the species was found to be well represented in that country. This serpent is green, with black spots or speckled markings.

March's Palm Viper, *Bothrops nigroviridis marchi* Barbour, (Figures 19 and 20). The form discovered in fair abundance in Honduras by Mr. March, represents a subspecies based upon scalation. The markings are similar to the typical form.

The Yellow-spotted Palm Viper, *Bothrops nigroviridis aurifera* (Salvin), occurs in Guatemala. It is green above and greenish yellow beneath, with scattered yellow spots.

Amaral notes the following about another palm viper, *Bothrops leptura,* occurring in Panama thence into northern South America: "Seems to be very poisonous, as its fangs occupy half or more the length of the mouth and its venom glands are quite long and thick."

The Hog-nosed Vipers: Three small species fall within this definition. The snout is sharply upturned with one, moderately so with a second, and pointed but not actually upturned with the other. These snakes in Central America are usually called "Chatilla" or "Tamagá." They occur over varied terrain, covering the greater portion of Central America and southerly Mexico. The genus ranges into South America.

The Nose-horned Viper, *Bothrops nasuta* Bocourt, (Figure 22), occurs in humid woodlands of eastern Central America, thence southward into Colombia and Ecuador. The snout bears an upturned proboscis-like appendage. Coloration is brown, with thirteen to twenty small black markings on each side of the back, these usually in alternation and separated by a pale line. Length is seldom beyond twenty-four inches.

Landsberg's Hog-nosed Viper, *Bothrops lansbergii* (Schlegel). The snout is carried forward to a sharp point slightly upturned. Coloration is brown, with a double row of darker markings on the back, generally separated by a paler line and often united to form a zig-zag chain. The length is usually under twenty-four inches. Occurrence is largely confined to the drier areas from southern Mexico, through Central America and into northwestern South America.

The Western Hog-nosed Viper, *Bothrops ophryomegas* Bocourt. The snout is sharp, but not upturned. The markings are similar to the two preceding species, but there is a greater number of the dorsal blotches—twenty-six to forty. This little viper inhabits the arid districts of western Central America from Guatemala to Costa Rica.

Other Species:

Godman's Viper, *Bothrops godmani* (Günther), (Figure 23). A small and rather stout species of brown or gray, inclined towards obscure markings, although some examples have a dorsal series of large, dark rhomb-like spots, arranged in zig-zag outline. Occasional specimens are quite vivid, somewhat like the North American copperhead. Average length is under twenty-four inches. Distribution appears to be limited to Honduras and Guatemala; possibly southern Mexico.

The Jumping Viper; "Mano de piedro"; or "Timba," *Bothrops nummifera* (Rüpp), (Figures 24 and 25). This snake seldom reaches three feet, and averages closer to two feet, but it stands out among the *Bothrops* species in having the proportionately stoutest body and largest head. The thick-set body is as incongruously heavy as the grotesque vipers of Africa. Its scales are also peculiar, being exceedingly rough, like those of the bushmaster. Mutilated specimens have led a few observers to the supposition that they had found young bushmasters in areas north of the actual range of that imposing species.

This snake receives its native name of "Mano de piedro" from its resemblance in form to a native implement used in the crushing of corn for tortillas. It is particularly savage, and in striking can make a short jump. This habit also exists with the irritable little hog-nosed vipers. The tales relating to the jumping of the "Mano de piedro" have been exaggerated, but specimens observed by the writer made a striking jump and slide that carried the serpent a full two feet forward. In striking from the side of a log or from a bank, where there is good purchase to lurch its coils, it may be able to jump as much as a yard. At any rate, a snake impelling itself bodily forward is startling, to say the least, and conducive to speculation and native exaggeration.

The fangs are proportionately short, and strangely enough, with all the native fear of reptiles and the branding of many harmless species as poisonous, this snake is but little dreaded, being declared harmless in some areas. The venom has a hæmolytic action, and is of lower toxicity than other species of *Bothrops*.

The body is gray or brown, with dark, black-edged, rhomb-like blotches, in a way, rather similar to the bushmaster, hence another reason for this species being sometimes mistaken for young specimens of the former. Distribution is broad, from Mexico as far north as Tuxpan, south through Central America to and including Costa Rica, and probably northern Panama.

Barba Amarilla; Fer-de-lance; "Tommygoff," *Bothrops atrox** (Linné), (Figures 30 and 31). How the name "fer-de-lance" came to such broad use among English speaking observers, when it originated among the Creole-French in a couple of small islands of the West Indies—Martinique and St. Lucia—may be explained by the fact that this dangerous viper became famous—or infamous—on those islands in particular, owing to their proportionately generous human population and the former abundance of this poisonous serpent. There has been much dramatic writing about this snake. It has figured in romantic tales of the islands, where there is a legend that it was imported to induce slaves to remain upon the plantations and make no attempts to escape or hide. The fer-de-lance is now rather rare upon these islands—although very common in Central and South America.

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* *B. lanceolatus* is now a synonym.

Among the native residents in the New World tropics, the term fer-de-lance is confined to those small islands. The Spanish-speaking residents of Central America appear to have never heard the term. In Spanish-America the name commonly used for this reptile is "Barba Amarilla," meaning the yellow-beard, and coming from the chin and throat being yellowish.

During the construction of the Panama Canal, these snakes were frequently encountered and the workers, hearing the Spanish term of "tommygoff," meaning nothing more or less than "snake," but not realizing its simple definition, felt it indicated something terse in the way of reptiles and applied the term to this viper—so that the appellation has become common in the region of the Canal.

The length is up to slightly over eight feet, though in some areas it runs much smaller—three to four feet. Coloration is variable, from gray to olive, brown, or even reddish, with dark, light-edged cross-bands or triangles, the apex of these extending to the center of the back. The form is moderately slender, with very distinct, lance-shaped head. Distribution is very extensive, beginning in southern Mexico, including the low-lying coastal areas of Central America, and the greater portion of South America, east of the Andes, except in elevated regions.

This is the most commonly observed poisonous snake of the Central American tropics, and one reason for its abundance is its large litters of young. The litters of three Honduran specimens were sixty-four, sixty-five and seventy-one —(Figure 38). The young produced by a six-foot mother were twelve inches in length. They are born fully provided with fangs.

The effects of the poison are dramatically sinister and rapid, the action being largely hæmolytic, destroying the red blood cells and breaking down the walls of the carrying vessels, which produces great extravasation. This is evident from the reddening of the eyes, discharge of blood from the stomach and mucous walls of the throat and mouth, the same conditions developing through the kidneys and bladder. The tissue about the wound is practically dissolved by rapid necrosis and gangrene. These effects are, however, efficaciously neutralized by serum produced by the several research laboratories in the tropics.

Serpents of this type are liable to be more abundant near slovenly human settlements than in the wilder areas, as they are attracted to such places by the rats and mice which accumulate in areas of ramshackle buildings and trash heaps.

The Bushmaster; "La Cascabela Muda" (the mute rattler), *Lachesis muta* (Linné), (Figures 1 and 39). This is the world's largest viper, but nowhere over its habitat, from southern Central America through tropical South America, does it appear to be abundant. It is more frequently found in Costa Rica and Panama than in the continental area to the south. Distribution extends into Nicaragua, but further observation must define just how far north it occurs. The writer was unable to locate records from Honduras, which thus appears to be too far north to be included in the distribution.

The bushmaster grows to be twelve feet long. These very large specimens are, however, particularly rare. Two adults in the writer's possession were eight and nine feet, respectively. They both deposited perfectly formed eggs, indicating full maturity. It is the only American viper which lays eggs, all the others producing living young. Reports of the largest specimens come from southern Costa Rica, Panama, or extreme northerly South America. This great crotaline serpent is of moderately slender build. A nine foot specimen shows no more bulk, when coiled, than a Texas or Florida rattlesnake slightly over five feet long.

Coloration is vivid. The body hue is pale brown, often pinkish. A series of large and bold, dark brown or black blotches extend along the body. These are wide on the back and abruptly narrow on the sides. The pattern is the reverse of the fer-de-lance, on which the blotches are narrow on the back, widening on the sides.

The bushmaster is a bold and in habits a particularly dangerous snake, inclined to deliberately edge towards the intruder, bringing the lateral, S-shaped, striking loop to nearer and better advantage. Its excessive length of fangs and great amount of poison render a well delivered stroke of the utmost gravity. It often warns of its presence by rapidly vibrating the tail, as do a number of the other tropical vipers, but the vibration of the bushmaster's tail is as rapid as the specifically provided warning tail of the rattlesnake. The tail of the bushmaster, among leaves, produces quite a loud, buzzing sound.

Deducting observations and records of captured examples, it seems that this snake prefers higher and drier ground than the fer-de-lance. Dr. Herbert C. Clark, Director of the Gorgas Memorial Laboratory, showed the writer two fair-sized specimens which had been killed on the Alajuela Cut, not far from the Canal Zone, by the construction gangs working on the new damming project to provide more water for Gatun Lake.

The Tropical Rattlesnake; "Cascabel," *Crotalus terrificus* Linné, (Figure 42), is the most poisonous of the rattlers, as well as the most savage. The venom differs from northern rattlesnakes and other New World vipers, in having a largely neurotoxic action, and is nearly colorless. It may be regarded as the most strongly toxic among the New World vipers, except that of the unique and isolated island viper, *Bothrops insularis,* found off the coast of Brazil. It is only by the considerably greater amount of venom discharged at a bite that the bushmaster may be rated as more dangerous than the rattlesnake.

This rattlesnake of the tropics has the widest range of any species of *Crotalus.* It occurs from central Mexico to northern Argentina. Moreover, it appears to be the only distinct species of *Crotalus* occurring over this wide area, with the exception of several essentially Mexican species—the Mexican Blotched Rattlesnake, *Crotalus polystictus* Cope, and Stejneger's Rattlesnake, *Crotalus stejnegeri* Dunn, the range of both in western and central Mexico. *Stejnegeri* is remarkable in having a tail proportionately much longer than other rattlesnakes.

The pattern of the tropical rattlesnakes is of the "diamond-back" design. In the arid areas of central and western Mexico, the rhombs are continued to the head. This is the subspecies *basiliscus.* From southeastern Mexico into northern South America, there are elongate bands on the neck, this form defined as the subspecies *durissus* (Figure 42).

Like the bushmaster, the "Cascabel" will slowly work its way towards an intruder, even deliberately glide forward to attack, carrying the neck in a lateral, S-shaped loop, in readiness to strike. The action is not a hostile rush, but an insolent and actual advance. While the rattle is heavily developed, the species is particularly dangerous in infrequently using it. It sometimes assumes a dramatic coil, with rattle buzzing steadily, but more often gives no more warning than a few quick side flings of the rattle, producing single harsh clicks. This is a sound well worthy of recognition in the higher ground of the tropics, as it may be immediately followed by the serpent's stroke—with no further warning.

The effects of the largely neurotoxic venom is described by March: "There is little or no bleeding from Cascabel bites; but death is preceded by blindness, paralysis and suffocation. . . . I believe that the idea holds over much of the range of the Cascabel that a bite will break a man's neck, regardless of the part of the body bitten. This is probably due to some selective action of the venom which causes complete paralysis of the neck. The man's head may, if he be held in a sitting position, slump forward on his chest, roll from side to side, or backward, in such a loosely connected way that the native cannot explain the condition as other than a broken neck."

Rattlesnakes in the Central American tropics frequent the higher, drier areas and thus their distribution but slightly overlaps that of the barba amarilla (fer-de-lance). They are abundant on the unwooded slopes of mountains back from the coast of Guatemala, Honduras, Nicaragua, and Costa Rica, or where the interior country may run into grassland or actually sterile areas. They are reported as particularly common in the mining areas, and a specific serum for their venom has been produced.

Length is up to six and seven feet. The body is heavy and inclined to ridge at the back. The head is proportionately small for such a powerful serpent.

The South American Species

The great continental area extending from approximately north latitude ten, past the equator to south latitude equivalent to the north of Newfoundland in the northern hemisphere, shows as distinct development in its reptile fauna as North America. The tropical portion is an area of great abundance of species of *Bothrops,* the genus of the lancehead vipers, and also of the coral snakes. Approximately fifteen species of the former occur, a dozen of which are essentially South American. At least one species of prehensile-tailed and arboreal *Bothrops,* or palm viper, is altogether South American and about twenty species of the coral snakes are indigenous.

It is important to mention that a number of the rear-fanged Colubrine snakes attain fair size in the American tropics. The fangs of some are quite long, and the bites of such reptiles might be distinctly poisonous. The New World rear-fanged serpents, however, have never been included among the dangerous reptiles. They seldom or never strike at an intruder with intent to use the fangs, which could be engaged only if the snake was to deliberately advance its jaws in the "chewing" motion of serpents utilized in holding or swallowing the prey. The toxicity of their venoms, moreover, is considerably lower than that of vipers and coral snakes. It is utilized in benumbing the prey, which consists largely of frogs and lizards. Fatalities from such serpent bites are practically unknown in the New World, but the larger members of the group should be regarded with caution. Some of them are known as "tree snakes" or "bush snakes," and have a lumpy, angular head, the eye with elliptical pupil. Owing to the lack of actual danger from this group, the absence of noted accidents, and the possibility of confusion by introducing representatives of its generous numbers among reptiles which deliberately employ highly perfected fangs, the rear-fanged, or opisthoglyph serpents are passed without further detail.

The Coral Snakes: Twenty-eight species of *Micrurus* have been scientifically listed. About twenty are indicated as being indigenous to South America. At least twelve species occur in Brazil, but few being actually indigenous to that country. Several are confined to the area north of the equator. Thus the coral snakes may be said to have their headquarters in equatorial America.

The tendency of several harmless snakes to "mimic" the dangerous species of *Micrurus* is more pronounced in South America than in Central America. Several of these non-venomous "imitators" are startling in their similarity to the poisonous species, as the South American coral snakes run to a greater variation in the width of the rings, and black on the outside of the yellow rings. (Note Figure 6.) This makes it particularly difficult to offer any fixed formula of gross differentiation in pattern to distinguish the inoffensive from the dangerous kinds. Some species of the innocuous genera *Pseudoboa* (Figure 10) and *Erythrolamprus* (Figure 11) are remarkable in their similarity of colors and ringed patterns to those of *Micrurus.* As representative examples of South American coral snakes, the following are selected:

Micrurus corallinus (Wied), (Figure 3), of the Lesser Antilles and tropical South America; *Micrurus frontalis* (Dumeril & Bibron), (Figure 4), of southern Brazil, Uruguay, Paraguay and Argentina, and *Micrurus lemniscatus* (Linné), (Figure 2), of the Guianas and Brazil. Here are examples of the differences among the species as to the ratio of yellow, red and black rings, the width and arrangement of the latter being particularly important. With *corallinus* the tendency is toward single black rings, narrowly margined with yellow or dull white; with *frontalis* there is black outside of the yellow rings (which are considerably broader), thus producing actually three black annuli; and with *lemniscatus* this is particularly pronounced, the yellow and black rings being so wide as to encroach upon and reduce the red, so typical of coral snake coloration. A length of four feet is not rare. These reptiles should be regarded as highly dangerous.

The South American Vipers: The resumé of the pit vipers of the South American continent is condensed, with the suggestion that the reader employ cross-reference to the detailed descriptions already given under Central America, of species occurring in both countries. The palm vipers or prehensile-tailed members of *Bothrops* are more numerously represented as to species in Central America, although at least one is indigenous to South America and two others occur in the northern portion.

The Green Palm Viper, *Bothrops bilineatus* (Wied), is leaf-green above, uniform or speckled with black. A yellow line or series of spots run along the outer row of scales. The range is essentially northern, or approximately north of south latitude fifteen, including Brazil, Bolivia, eastern Peru and Ecuador. The native name is "Surucucu patiabo."

Schlegel's Palm Viper, *Bothrops schlegelii* (Berthold), (Figure 21), has already been described in the Central American fauna. Both the olive and yellow phases occur in South America. There are records from Colombia and Ecuador. It probably ranges into western Venezuela and northwesterly Brazil.

Bothrops leptura, another prehensile-tailed species, is recorded from western Colombia. It also occurs in Panama.

The hog-nosed vipers are represented in the northerly portion of South America by *Bothrops lansbergii* (Schlegel), so commonly found in the Central American tropics. The range is into Colombia, Venezuela and northern Brazil. Regarding its occurrence in Colombia, Amaral writes: "The 'Fer-de-lance' (*B. atrox*) which is the main problem in the plantations in Central America, seems to be comparatively uncommon in Santa Marta, its place being taken by another venomous species seldom found elsewhere but surprisingly common in the Santa Marta district. This is the dry-land Hog-nosed Viper (*Bothrops lansbergii*), which constitutes about 50 per cent of the Rio Frio catch. This species has been found among leaves in dry forests and also under bushes, dead trees, etc., so that it is anticipated that with the progressive clearing of the jungle, it will probably invade the banana plantations and may become dangerous to the laborers in that section."

The Island Tree Viper, *Bothrops insularis* (Amaral), (Figure 27). Unique in its genus in appearing to be confined to a small island composed of steep, rocky slopes, with separated patches of tropical vegetation. This island has barely three-quarters of a square mile of surface. It is known as Queimada Grande and situated on the coast of the State of Sao Paulo, about forty miles southwest of the Bay of Santos.

This curious viper is pale brown, with rather widely separated cross bands. Adult length is between three and four feet.

There are many birds on the island, some of them possibly resting there during incidental migrations from outjutting points of the mainland or the other islands in the vicinity. Hence these snakes, which occur in abundance, have plenty of food, and appear to feed, when adult, upon nothing but birds, for the immediate killing of which they have developed a particularly powerful venom. Experiments have demonstrated that this isolated viper has the most highly toxic venom of any species of its genus.

Bothrops insularis is not immediately related to the palm vipers, although it is arboreal and has a partially prehensile tail. It seems to be more closely allied to the terrestrial species of *Bothrops,* and among them, the following may be listed to indicate the extent of the genus:

Bothrops pulcher (Peters), of the Andes of Ecuador; *Bothrops micropthalmus* Cope, of Peru and Ecuador; *Bothrops pictus* (Tschudi), of Peru; *Bothrops xanthogrammus* (Cope), of the mountains of Colombia and Ecuador; *Bothrops cotiara* (Gomes), of Brazil; and *Bothrops castelnaudi* Dumeril & Bibron, of Brazil, Ecuador and eastern Peru. The distribution of these species will probably be found to include broader areas as further studies develop of South American herpetology. *Bothrops ammodytoides* Leybold, seems to be the most southerly species and confined to the pampas of the Argentine and northeastern Patagonia. It is small, with a wart-like protuberance upturned on the snout.

Continuing the list, is a series illustrated by photographs from life. As they range through country where the language is largely Portuguese or Spanish, the matter of "common" or "popular" names has been guided by designation in the native language where they commonly occur, with occasional digressions with species of particular prominence.

Bothrops itapetiningae (Boulenger) is known in Brazil as "Boipeva" and "Cotiarinha." It is rather small, of ruddy brown, with a series of dorsal patches which may fuse with similar blotches on the sides. It is of rather scant occurrence and comparatively restricted distribution. (Figure 26).

Maximilian's Viper; "Jararaca"; "Urutu"; "Jararaca do rabo branco," *Bothrops neuwiedii* (Wagler), (Figures 28 and 29), is a fair-sized species, which, in Brazil, is one of the most widespread of the pit vipers, occurring in all of the northeastern, Central, southeastern and southern states. It also extends into Argentina and northern Paraguay. It shows considerable variation in markings and Amaral has named several subspecies. The general coloration is olive or brown, with a double row of dark, triangular markings along the back, these being in alternation, or sometimes fused. At the base of each triangle on the sides are two spots of similar color.

The most handsomely marked member of the genus is a large species commonly known as "Urutu," *Bothrops alternatus* Dumeril & Bibron, (Figure 37), attaining a length of five feet, quite heavy of body, and characteristic in the deep brown chocolate crescents on the sides, these vividly edged with yellow or white. This attractively-patterned species occurs in southerly Brazil, Paraguay, Argentina and Uruguay.

There are two rather similar species called the Jararaca (fer-de-lance), and their distribution may be thus defined:

Bothrops atrox (Linné), (Figures 30 and 31), the "barba amarilla" of Central America, "fer-de-lance" in Martinique and St. Lucia, and the "Barcin" and Mapepiré balsayn in Tobago and Trinidad, occurs abundantly in Venezuela, Colombia, Ecuador, easterly Peru, Bolivia, the Guianas and southward in Brazil, to approximately latitude 23°s.

Bothrops jararaca (Wied), also called the Jararaca, commonly occurs in Brazil, from about south latitude 10° to northern Argentina and northeastern Paraguay.

The Jararacucu, *Bothrops jararacussu* Lacerda, (Figures 33, 34, 35 and 36), is proportionately thicker-bodied, with a bigger head than the former. Its markings are likewise different. The paler outline markings of the blotches dominate the pattern, and there is a greater amount of the lighter colors on the sides. This is a quick and savage snake, and its big head, with excessive length of fangs, renders it extremely dangerous. The range is largely confined to Brazil.

The Bushmaster, "Surucucu," or "Mapepiré Z'Ananna" in Trinidad, *Lachesis muta* (Linné), (Figures 1 and 39), already considered in detail under the Central American section of this article, ranges over a considerable portion of tropical South America, including the northern states of Brazil, but is nowhere common. It may be immediately distinguished by its exceedingly rough body scales and the smooth plates under the tail being replaced at the end by small scales and a stout, sharp spine.

The Tropical Rattlesnake, *Crotalus terrificus terrificus* (Laurenti), (Figure 43), has been treated in detail under Mexico and Central America, where its northerly races indicate two distinct subspecies. Of these, *durissus* ranges into Venezuela and Colombia. In the Portuguese speaking countries it is known as "Cacavel" and "Boicininga" and in Spanish as "Cascabel." Its range is over the greater part of South America in the drier, elevated areas, to southern Brazil and the northern Argentine. In the northern portion of the continent, the bands on the neck are much elongated, as with Central American specimens. Examples from the greater continental area have shorter neck bands, but all exhibit the characteristic rhomb-like marking of the back.

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Extracting venom from a fer-de-lance. The first step in the preparation of serum. The venom is injected (in small quantities) into horses to render them immune and thus produce an antivenomous serum.

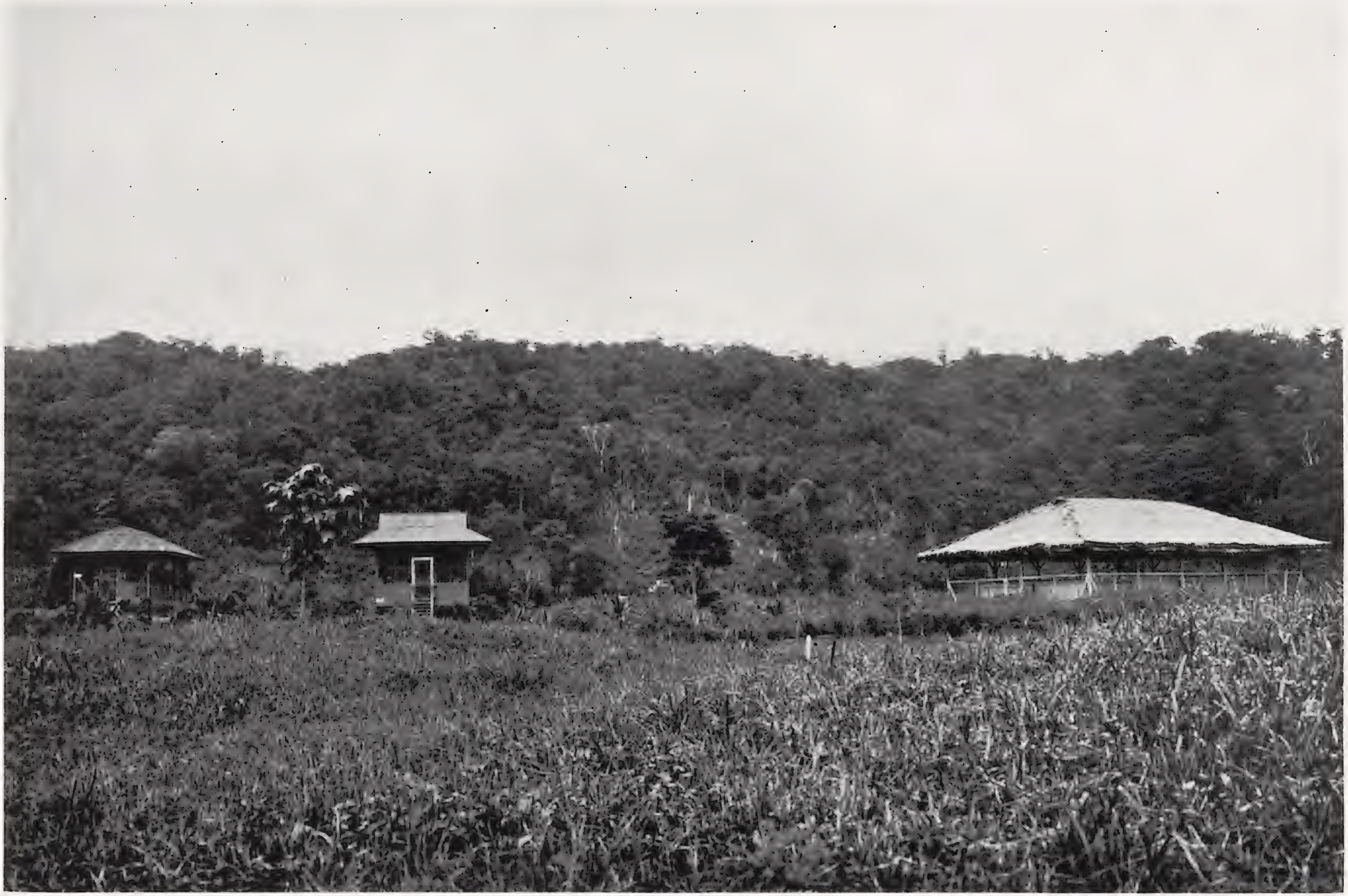
Antivenines for Snake Bite

The pioneers in production of antivenines for the bites of New World serpents were Doctors Vital Brazil and Afranio do Amaral. Dr. Amaral is now Director of the splendid organization known as the Instituto Soro Therapico, at Sao Paulo, Brazil, which is conducted under the auspices of the government. Dr. Brazil is now Director of an equally modern plant known as the Instituto Vital Brazil, which is situated at Nictheroy, a suburb of Rio de Janeiro. These institutions produce specific grades of sera for the different types of poisonous snakes. A grade is prepared to neutralize the venoms of the *Bothrops* group, which is particularly marked in its haemolytic action, and another for that of the tropical rattlesnake, which indicates powerful neurotoxic and haemotoxic elements. Another is produced to counteract the largely neurotoxic venom of the coral snakes. There is also a polyvalent serum, which is not so efficacious as a specific type, but intended for use when the bite is from an undetermined serpent. These sera are largely available south of the equator.

North of the equator, the Serpentarium at Tela, Honduras, jointly maintained by the Antivenin Institute of America, Harvard University and the United Fruit Company, collects venoms from the *Bothrops* types and the tropical rattlesnake, for preparation of such specific sera. These venoms are sent to the laboratory at Glenolden, Pennsylvania, where the immunization of horses and consequent developments to the perfected antivenin are conducted.

The Antivenin Institute of America also prepares a serum for general use in the United States, where the venoms of the pit vipers—the rattlesnakes, copperhead and moccasin, are so similar that a polyvalent serum is practicable and efficacious. The venoms of these North American vipers is largely haemotoxic. As the danger from the coral snakes in the United States is very slight—as indicated from the extreme infrequency of accidents—no specific serum has been produced for North America.

From this resumé of different types of serum, it will be understood that anyone going into country where poisonous serpents are common, should use care in being provided with the proper kinds. All of these sera are hypodermically administered.



Serpentarium at Tela, Honduras. This institution is maintained jointly by Harvard University, the Antivenin Institute of America and the United Fruit Company for the purpose of extracting venom from native reptiles, and producing serums. The large thatched structure is a shaded snake pit. One of the smaller buildings contains a photographic dark-room, and the other screened cages for study of individual specimens. From a photograph by Anton Vestby.

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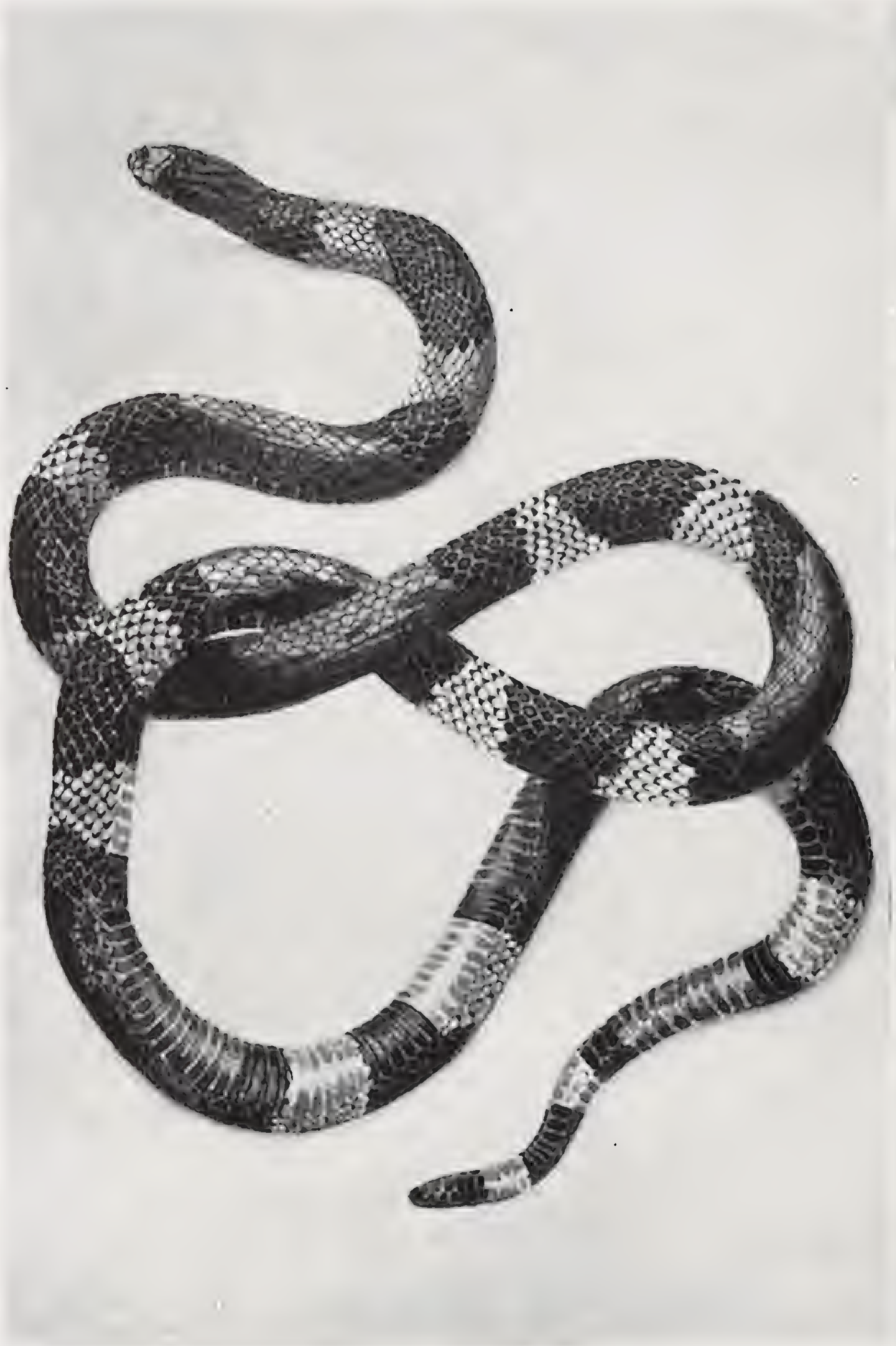
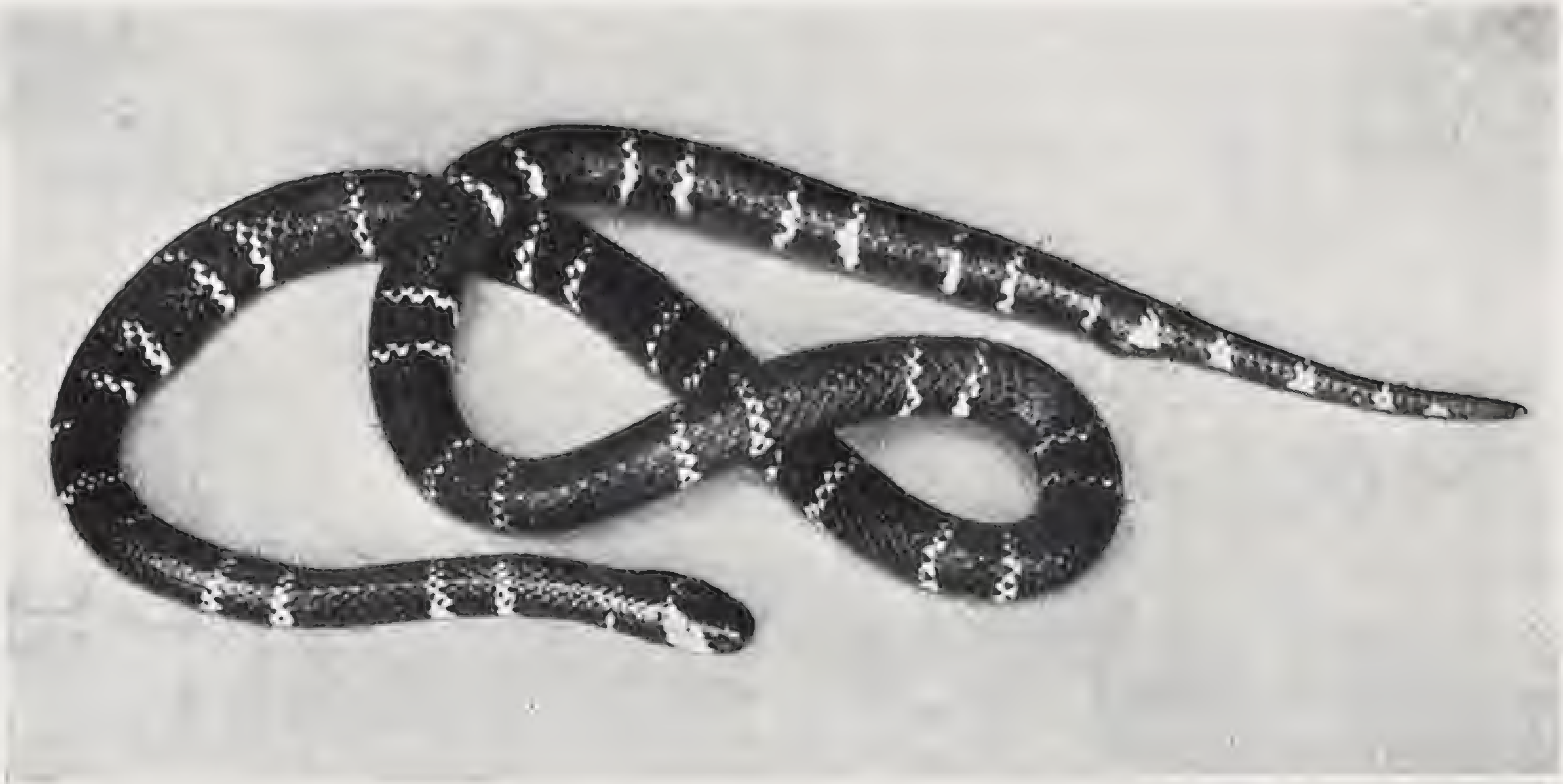
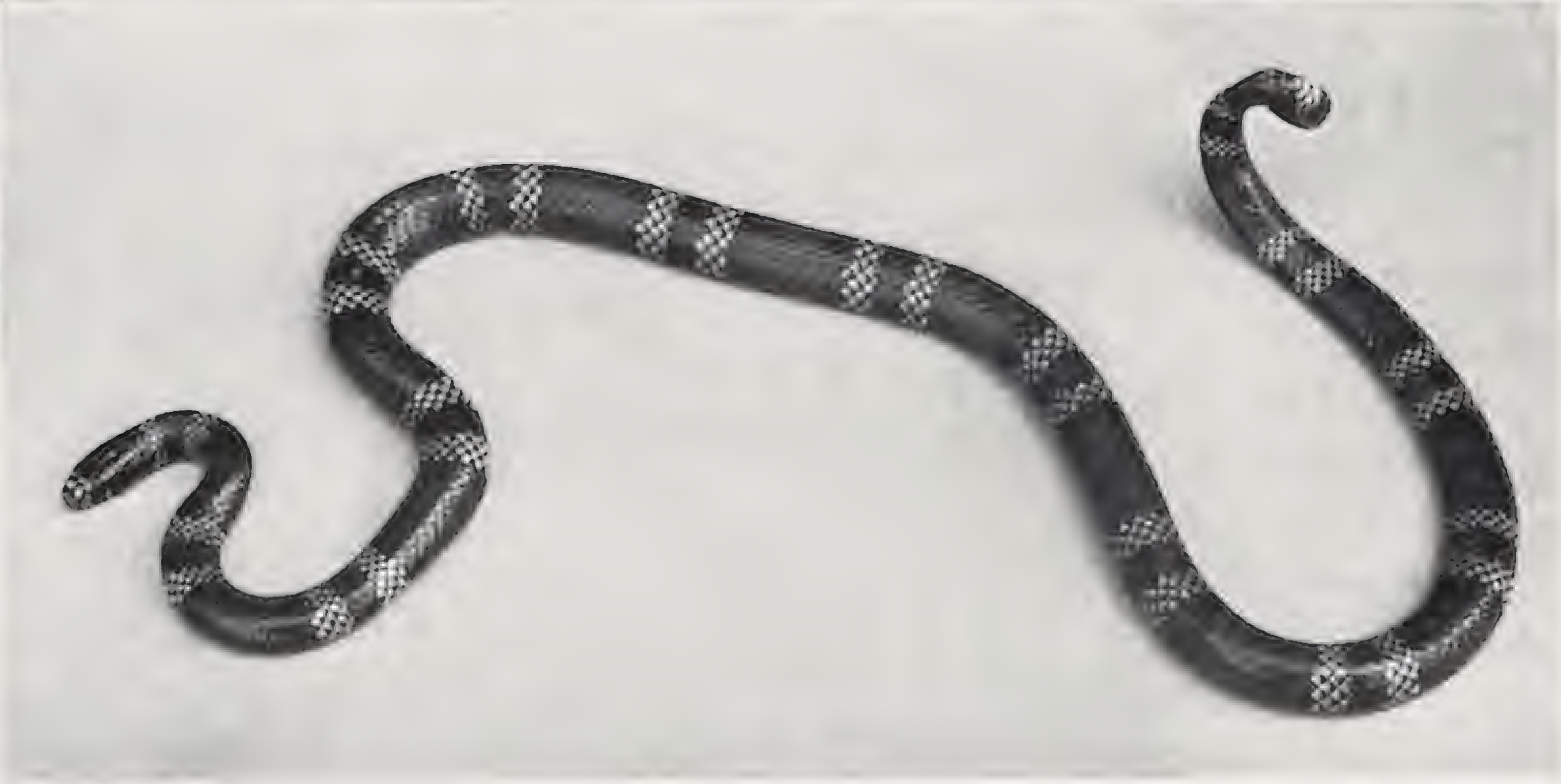




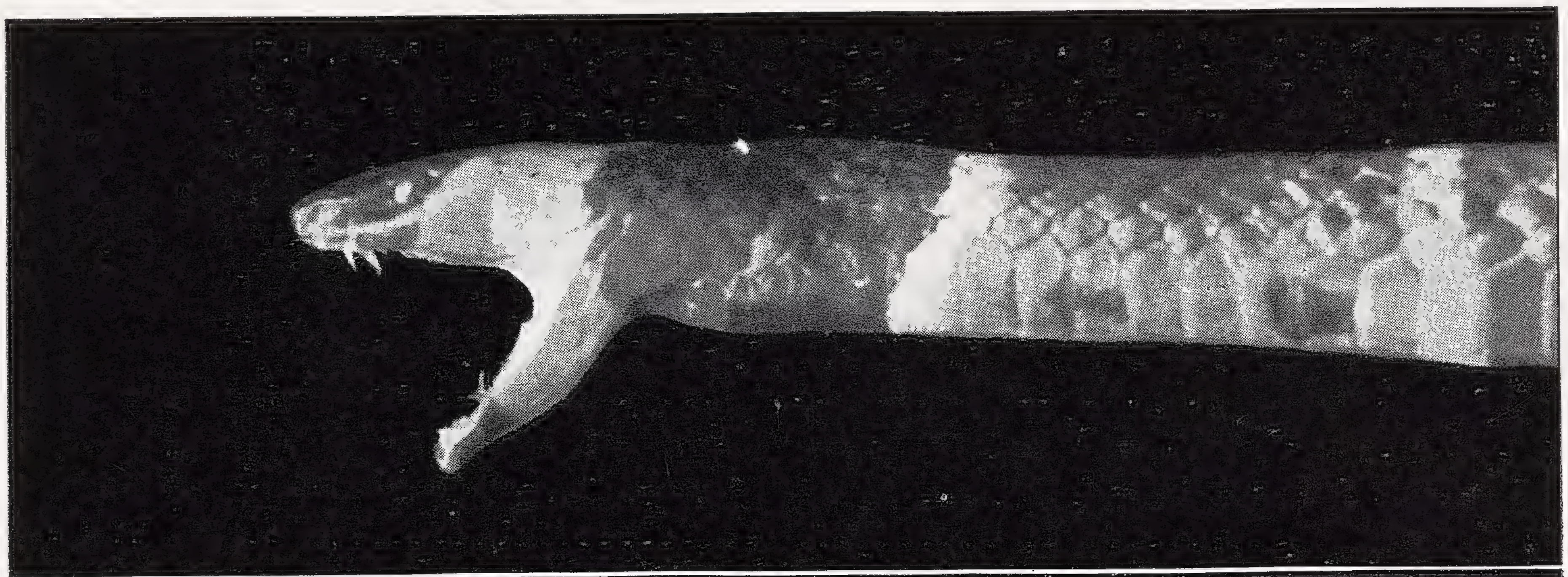


Poisonous Coral Snakes

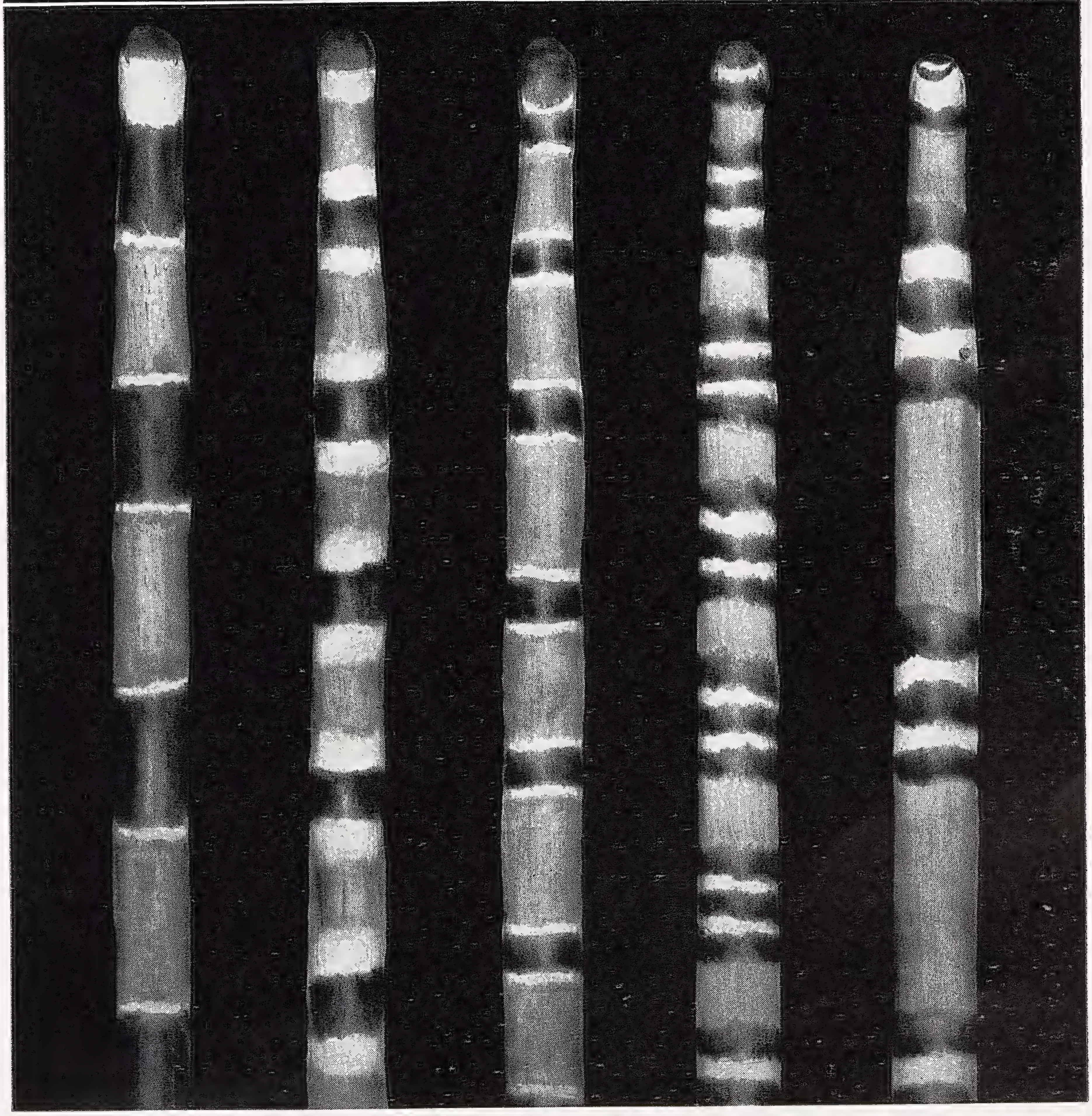
Left—Fig. 2. *Micrurus lemniscatus.* The Guianas and Brazil. The yellow rings are wide and heavily margined on the outside with black.

Upper right—Fig. 3. *Micrurus corallinus.* Tropical South America, and the Lesser Antilles. The other extreme in width of the yellow rings, which are in immediate contact with the red areas.

Lower right—Fig. 4. *Micrurus frontalis.* Southern Brazil to Argentina. Intermediate between *Figures* 2 and 3. The yellow rings are moderately margined outside with black. Photographs courtesy of Dr. Afranio do Amaral.



Upper—Fig. 5. Head of Coral Snake, *Micrurus*. Showing the very short poison fangs, which are permanently erect. This is a quite different development from that of the vipers (*Figures* 12, 13 and 14).



Lower—Fig. 6. Patterns of coral snakes—drawn by the author. The gray areas indicate the red. From right to left the patterns indicate: *M. fulvius*, southeastern United States; *M. euryxanthus*, southwestern United States and Mexico; *M. corallinus*, *M. lemniscatus* and *M. frontalis*, South America.

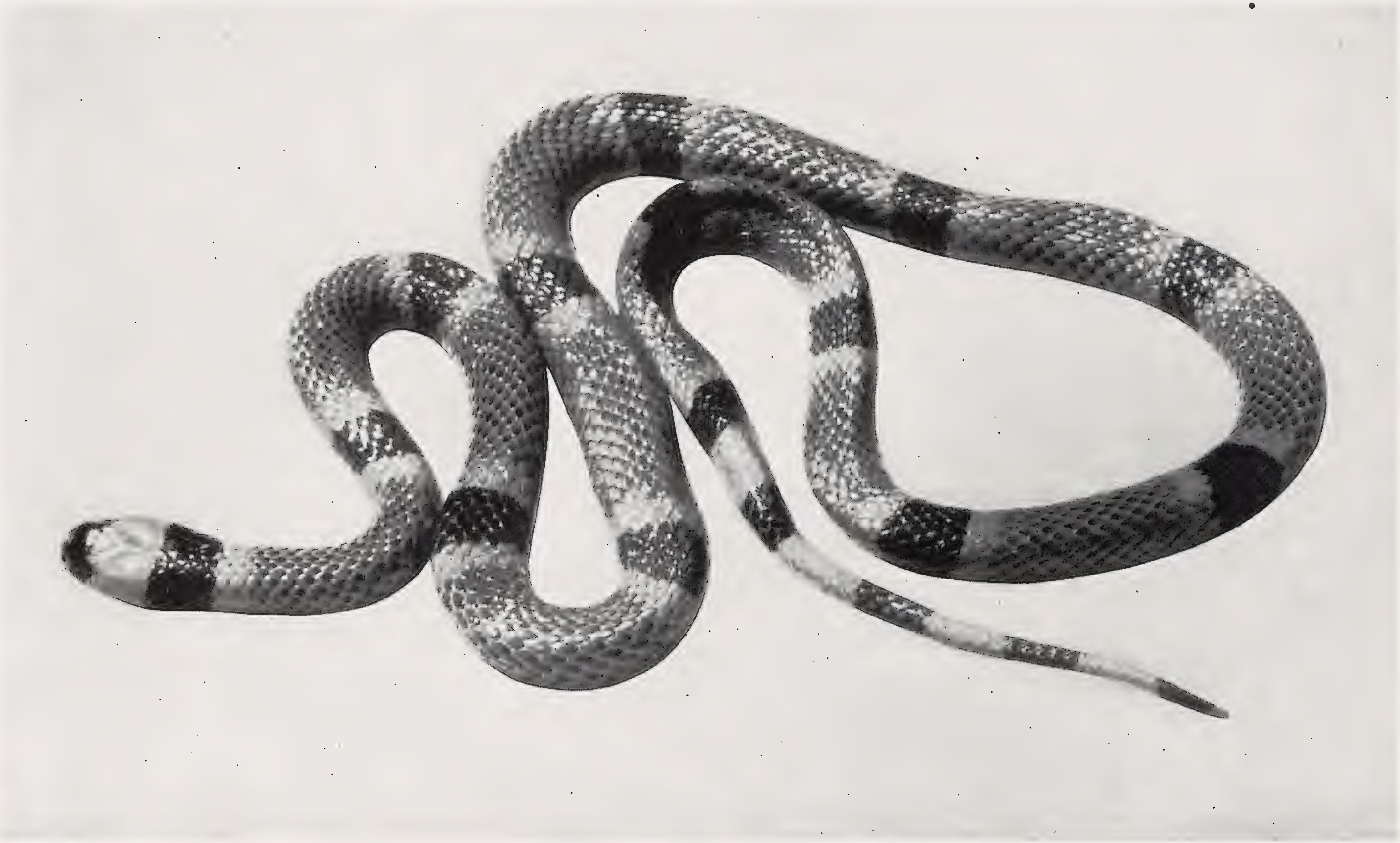
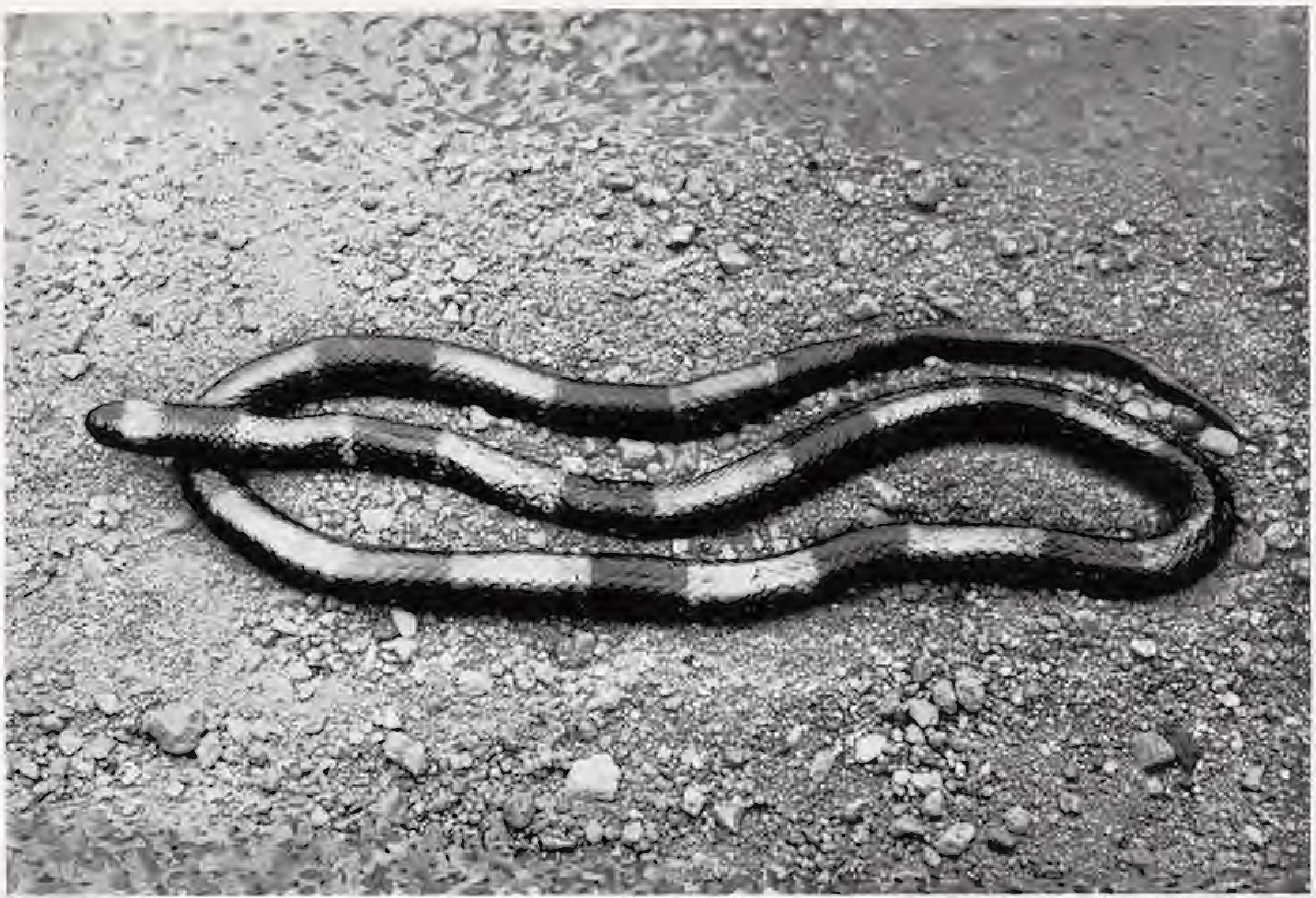
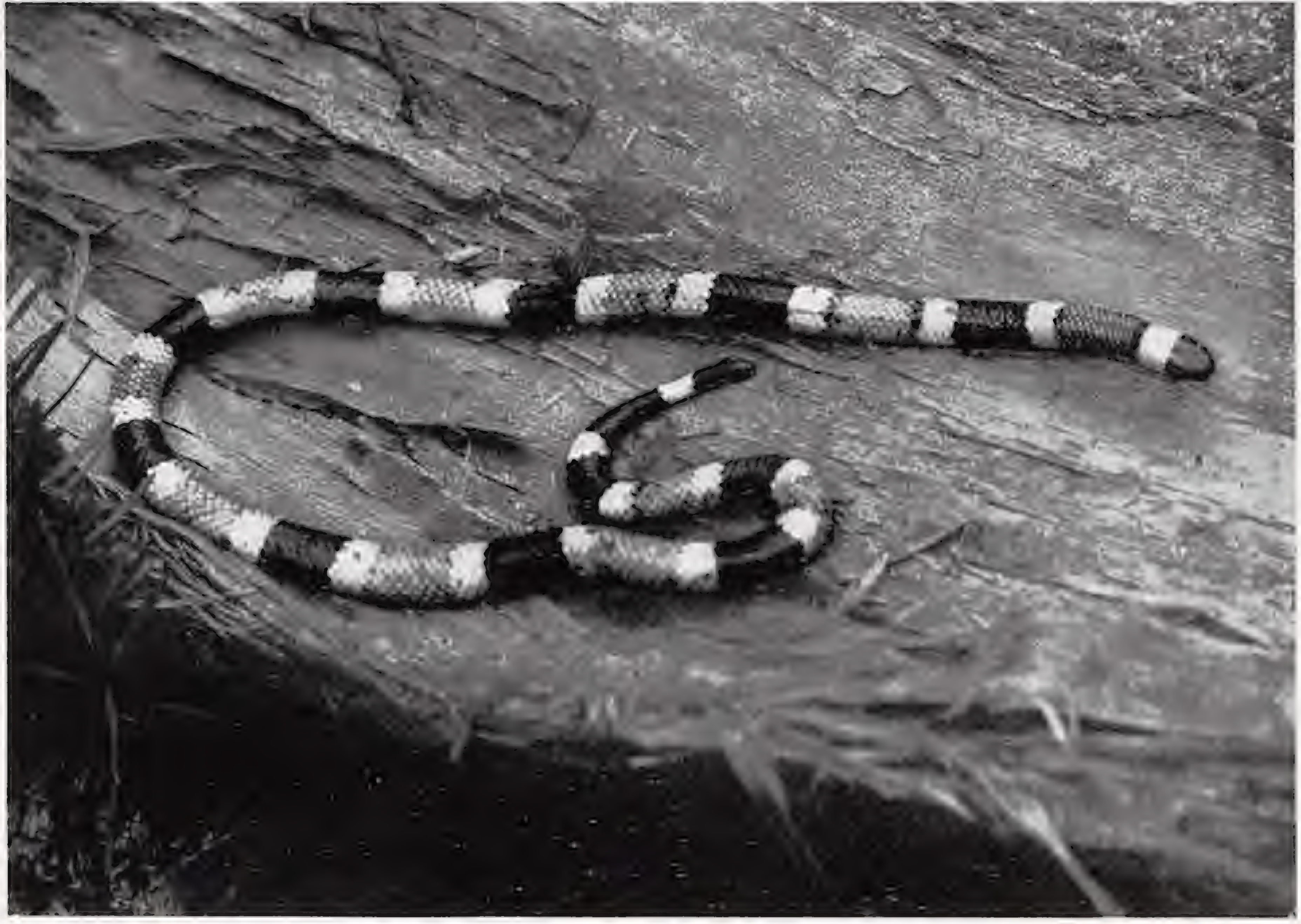


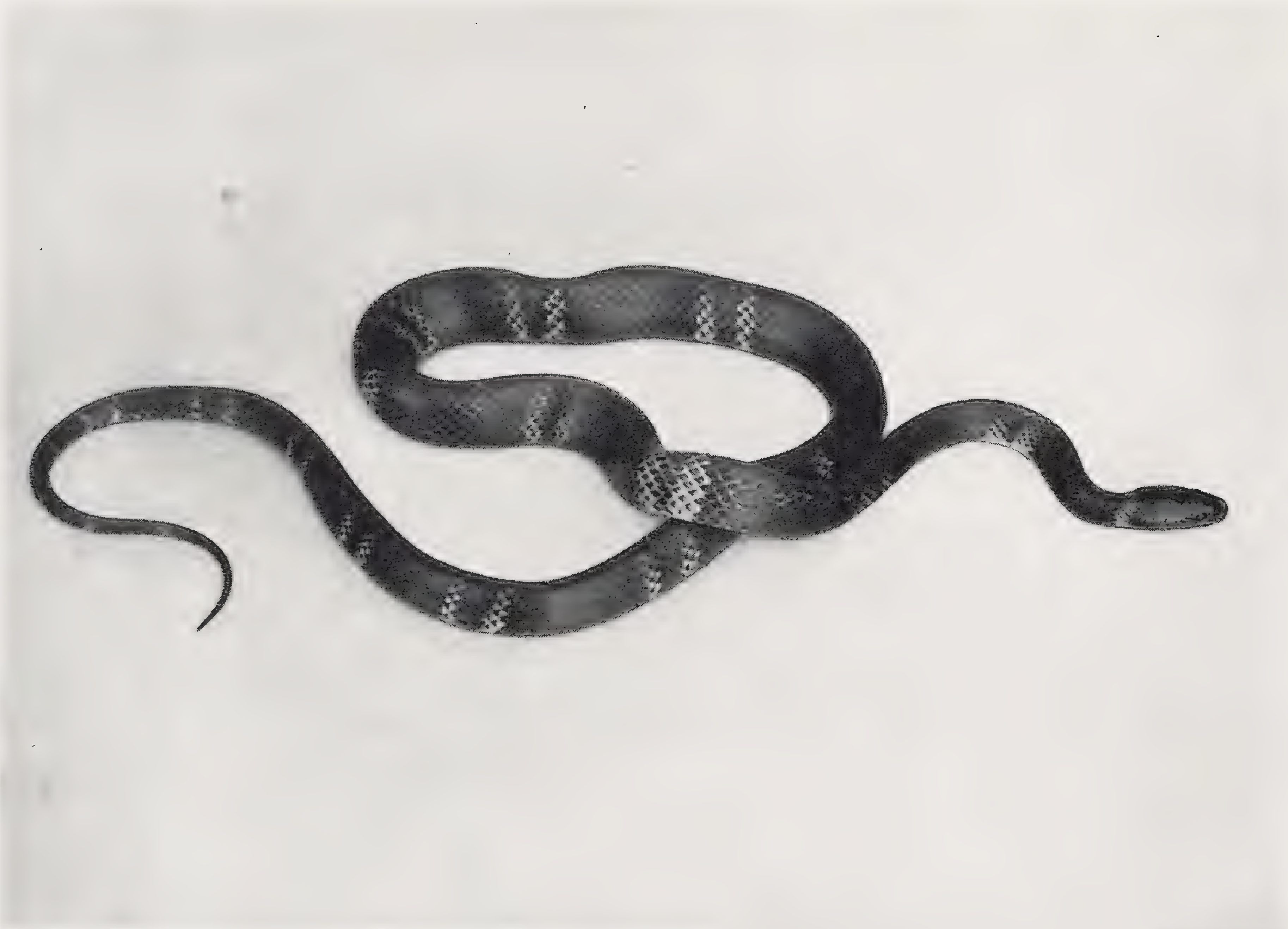
Fig. 7. Central American Coral Snake, *Micrurus nigrocinctus*. The average length of a large tropical coral snake is three feet. Occasional specimens are larger. These slender-bodied, narrow-headed serpents, with their pretty patterns of bright red, yellow and black, look anything but dangerous. In reality they are extremely poisonous, and related to the Old World cobras. They do not strike, but deliberately bite if touched or stepped on. Their venom attacks the nerve centers, and bites of such snakes are often fatal. Photograph by Anton Vestby.

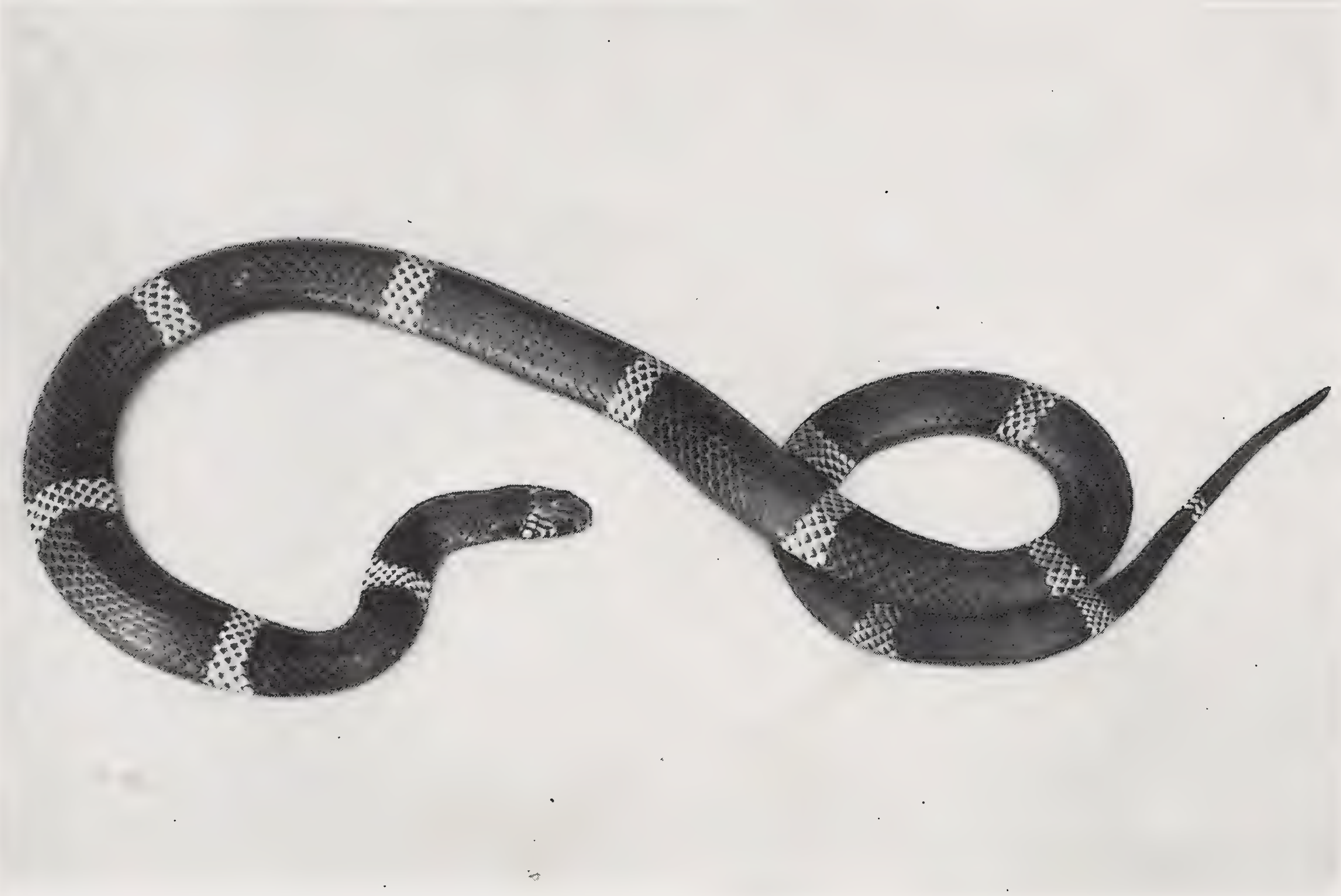




Upper—Fig. 8. Coral Snake; Harlequin Snake, *Micrurus fulvius.* Occurs in the southeastern United States. It is secretive and of burrowing habits, though sometimes seen prowling after rains. It feeds upon the young of other snakes and small lizards.

Lower—Fig. 9. Sonoran Coral Snake, *Micrurus euryxanthus.* Found in the extreme southwestern United States and northern Mexico. These extremely dangerous and deceptively pretty reptiles form an extensive genus of considerably over two dozen species, ranging from the southern United States to Argentina.

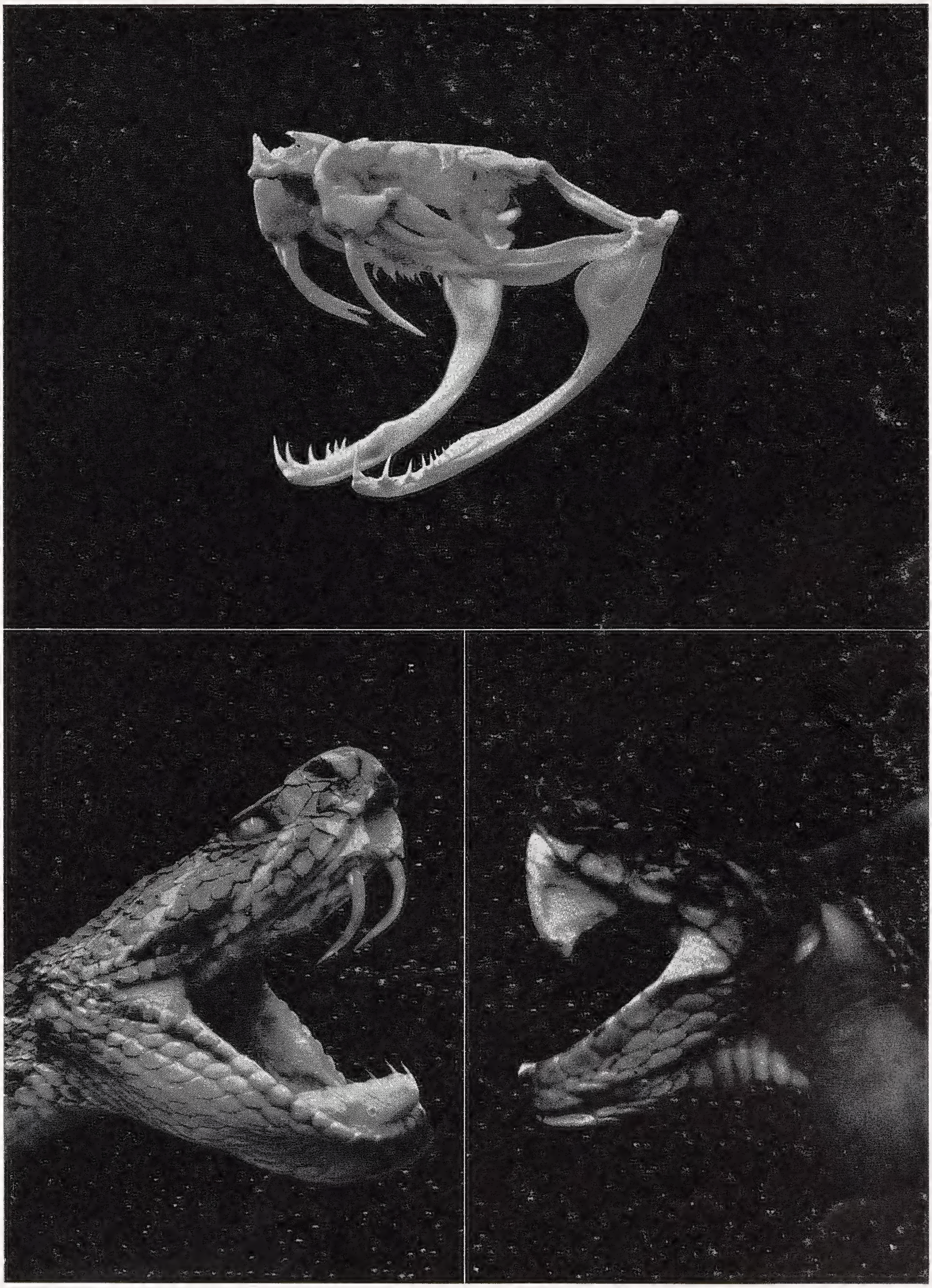




Harmless Species Resembling Coral Snakes.

Upper—Fig. 10. A Brazilian serpent, *Pseudoboa trigeminus*, with pattern of red. black and yellow bands of remarkable similarity to that of the poisonous coral snake.

Lower—Fig. 11. Another Brazilian species, *Erythrolamprus aesculapii*, with red. black and yellow bands. There is similarity to the poisonous coral snakes in coloration, but the yellow rings are single and margined with black, a reverse from the usual pattern of the dangerous reptiles. Harmless "mimics" of the coral snakes are found wherever the latter occur. Photographs courtesy of Dr. Afranio do Amaral.

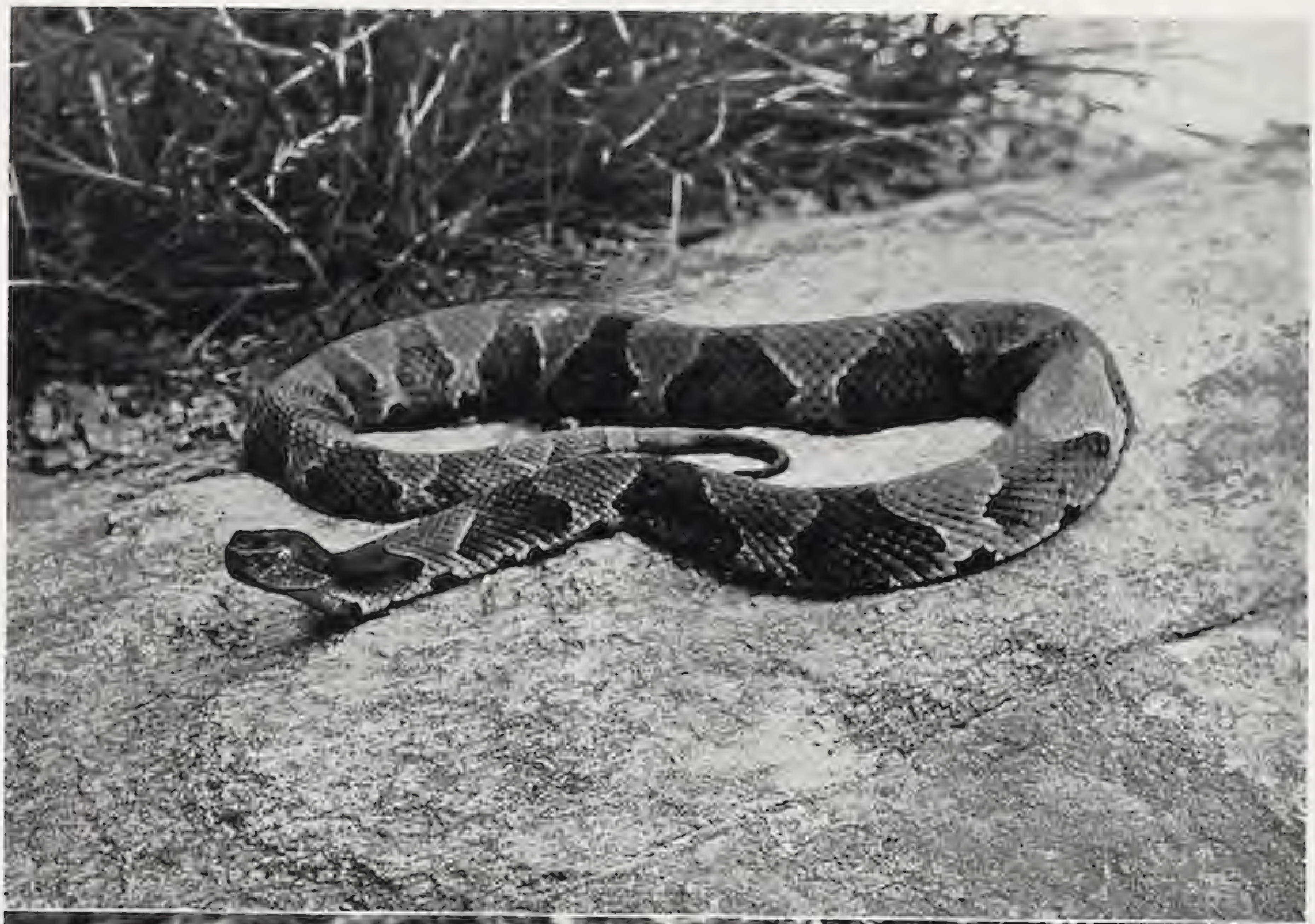


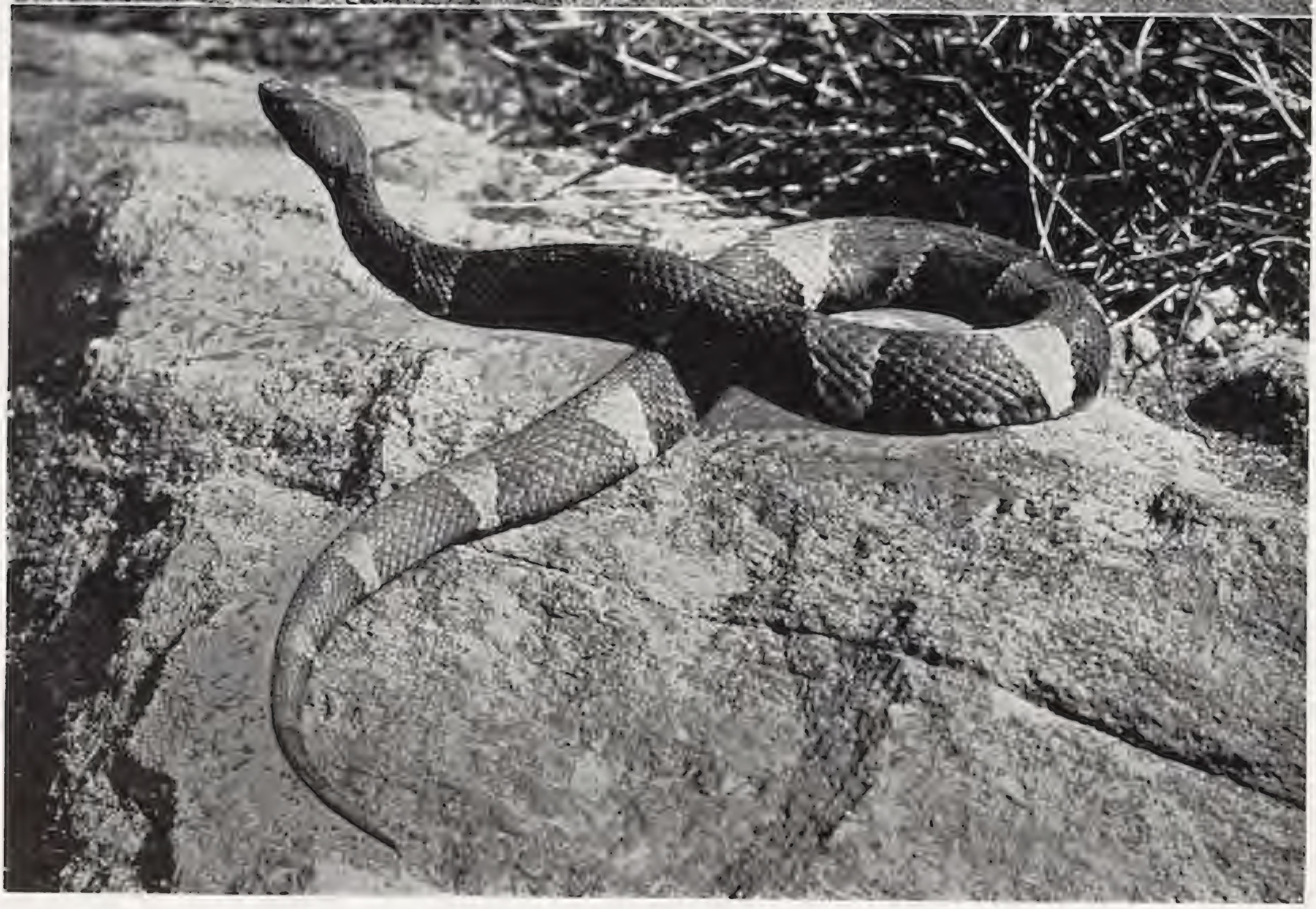
Heads of Viperine Snakes.

Upper—Fig. 12. Skull of Bushmaster, showing the poison fangs in upper jaw. These are hollow, with opening at tip like a large hypodermic needle. They fold back when the mouth is closed. There are double fangs on the right—one ready to be shed.

Lower left—Fig. 13. Head of Diamond-back Rattlesnake.

Lower right—Fig. 14. Head of Fer-de-lance, showing membranous sheath normally coverings the fangs and which is pushed upward in biting.

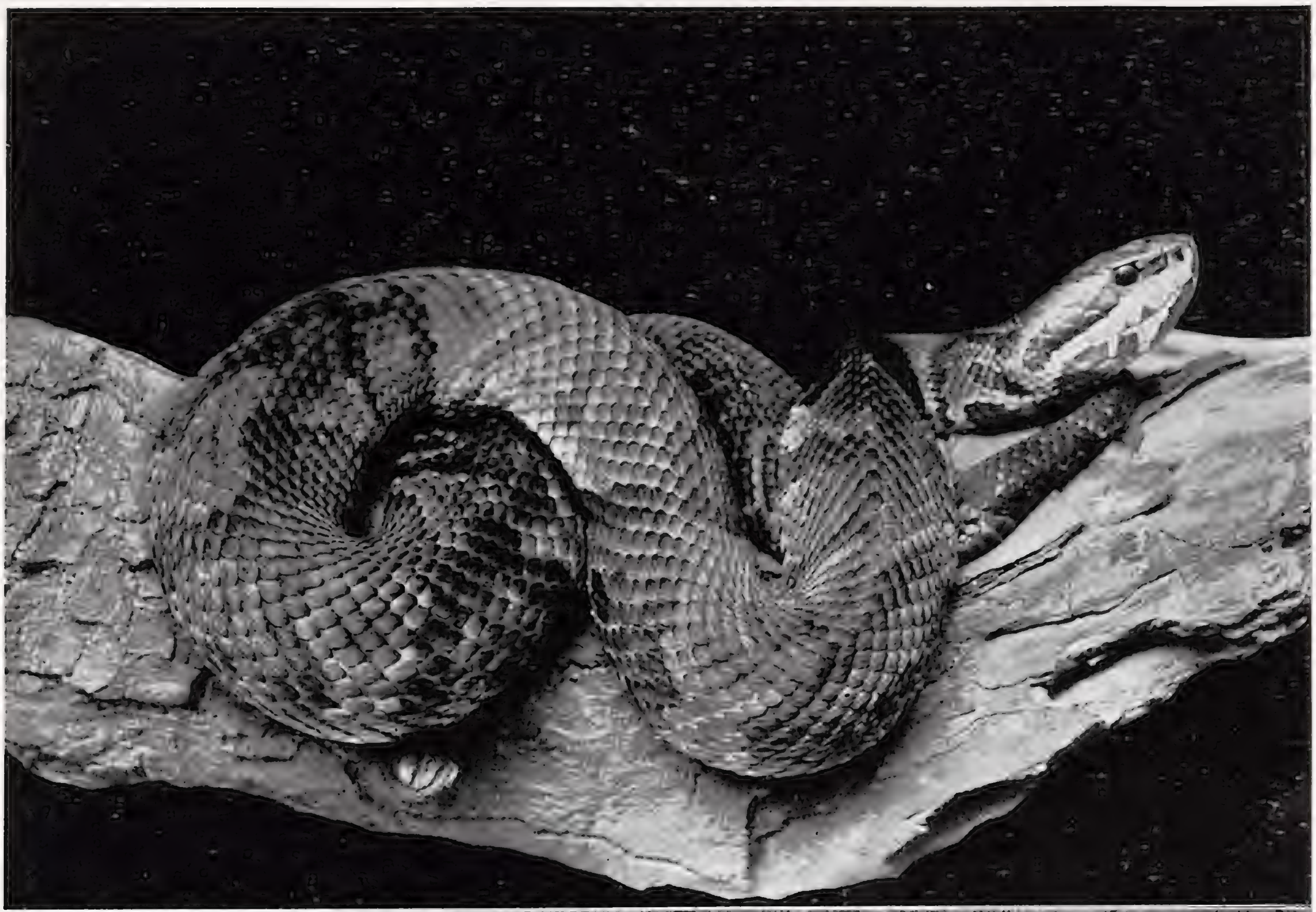


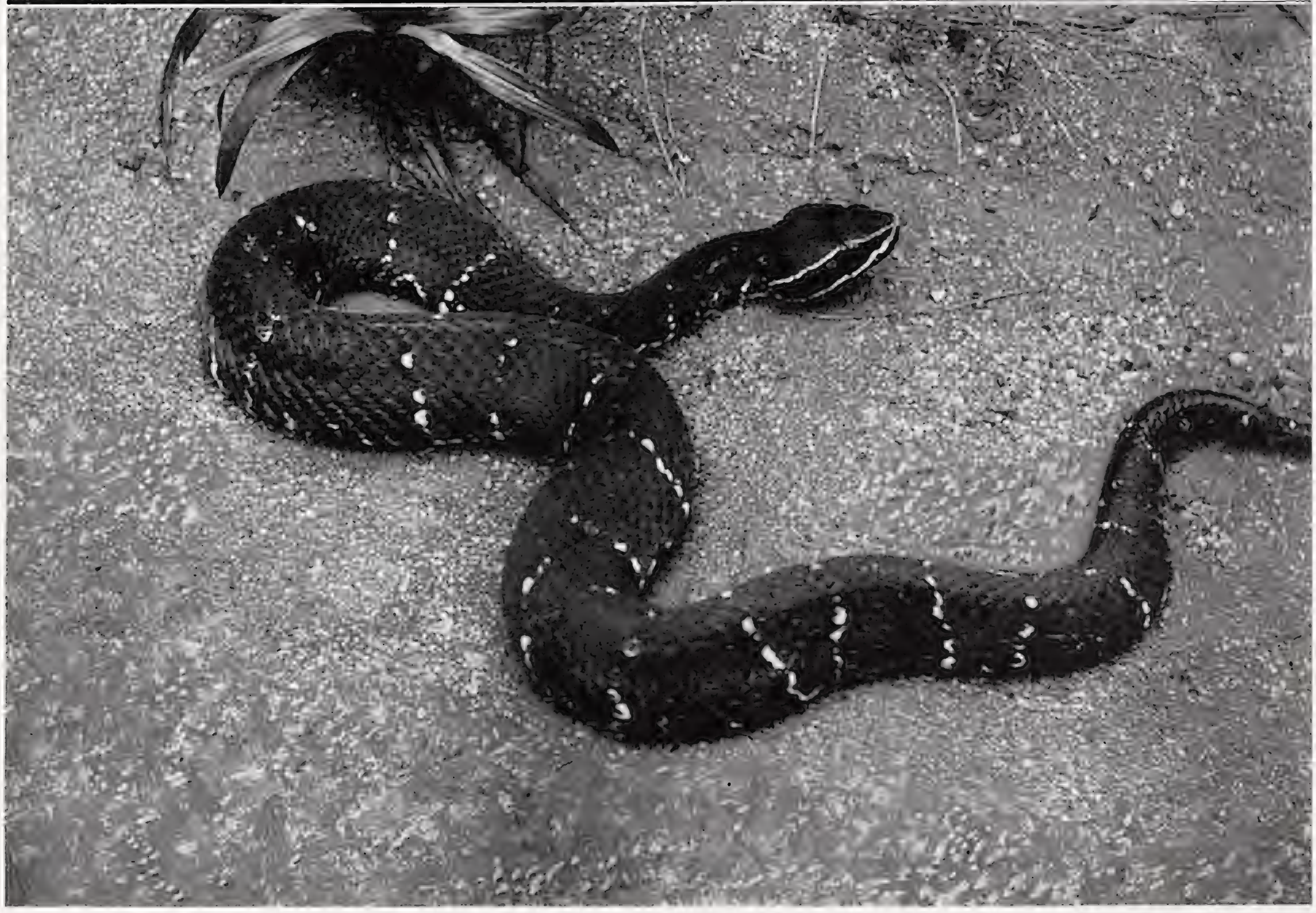


The Copperhead Snake, *Agkistrodon mokasen.* (Eastern and western phases.)

Upper—Fig. 15. Ranging from Massachusetts to northern Florida and to the Mississippi Valley, the eastern phase is fairly constant in pattern, although the paler areas between the dark brown blotches vary from gray and tan to pinkish brown or reddish hue. When coiled, this serpent closely blends with fallen leaves and often seeks to hide where dead leaves carpet the ground.

Lower—Fig. 16. A Texas Copperhead. The bands are fewer in number and much wider than with eastern specimens.





Upper—Fig. 17. Water Moccasin; "Cotton-mouth" Snake, *Agkistrodon piscivorus*. Water snakes of several species inhabit the United States but this is the only poisonous aquatic serpent within that area. It is abundant in the Southeast and attains a length of five feet. The term "cotton-mouth" comes from the mouth parts being whitish. It will open its mouth and threaten an intruder.

Lower—Fig. 18. Tropical Water Moccasin, *Agkistrodon bilineatus*. The pattern is highly decorative, as if the reptile were marked with white enamel. This is a savage and very dangerous snake, restricted to southerly Mexico and northern Central America.

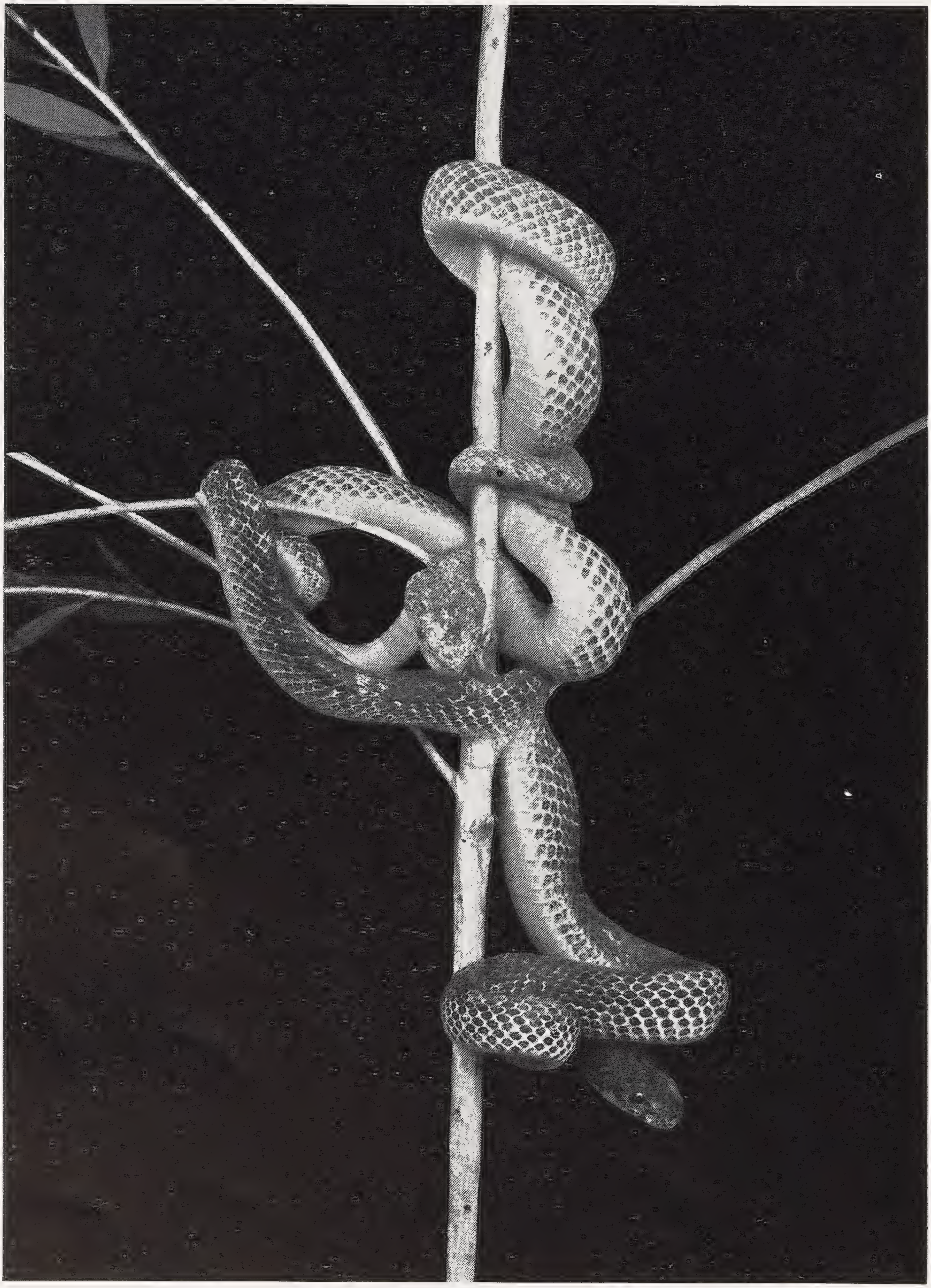
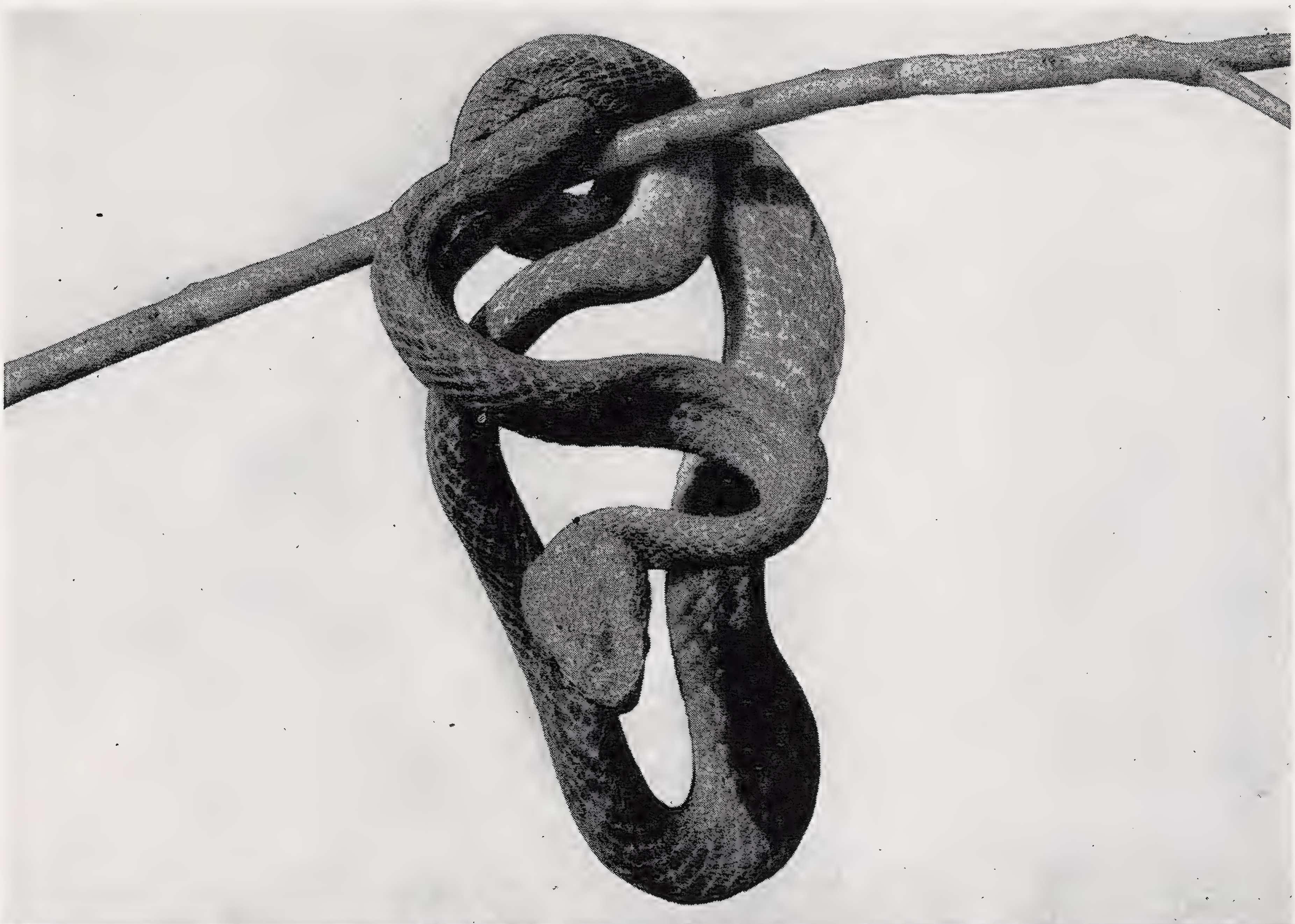
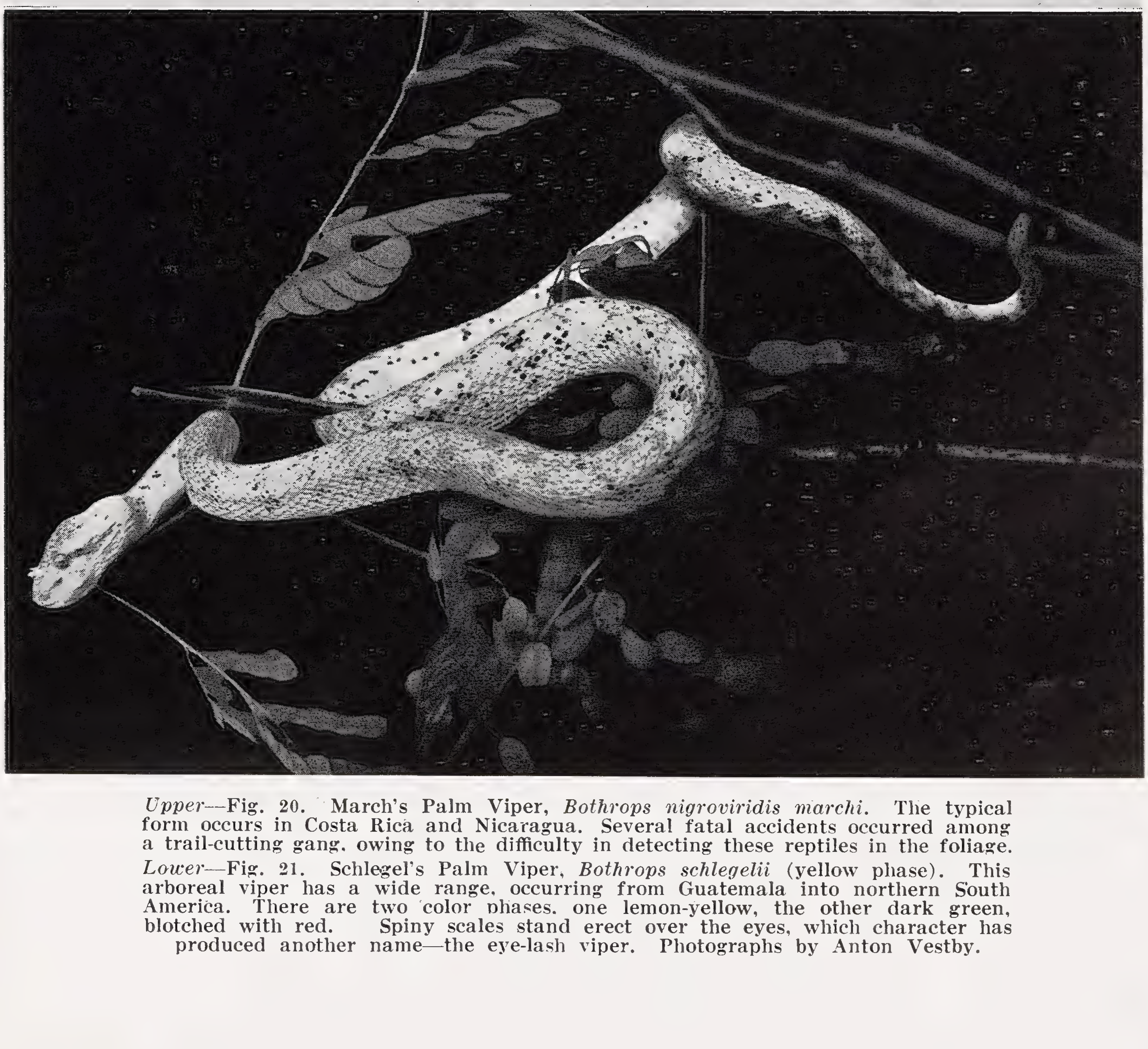


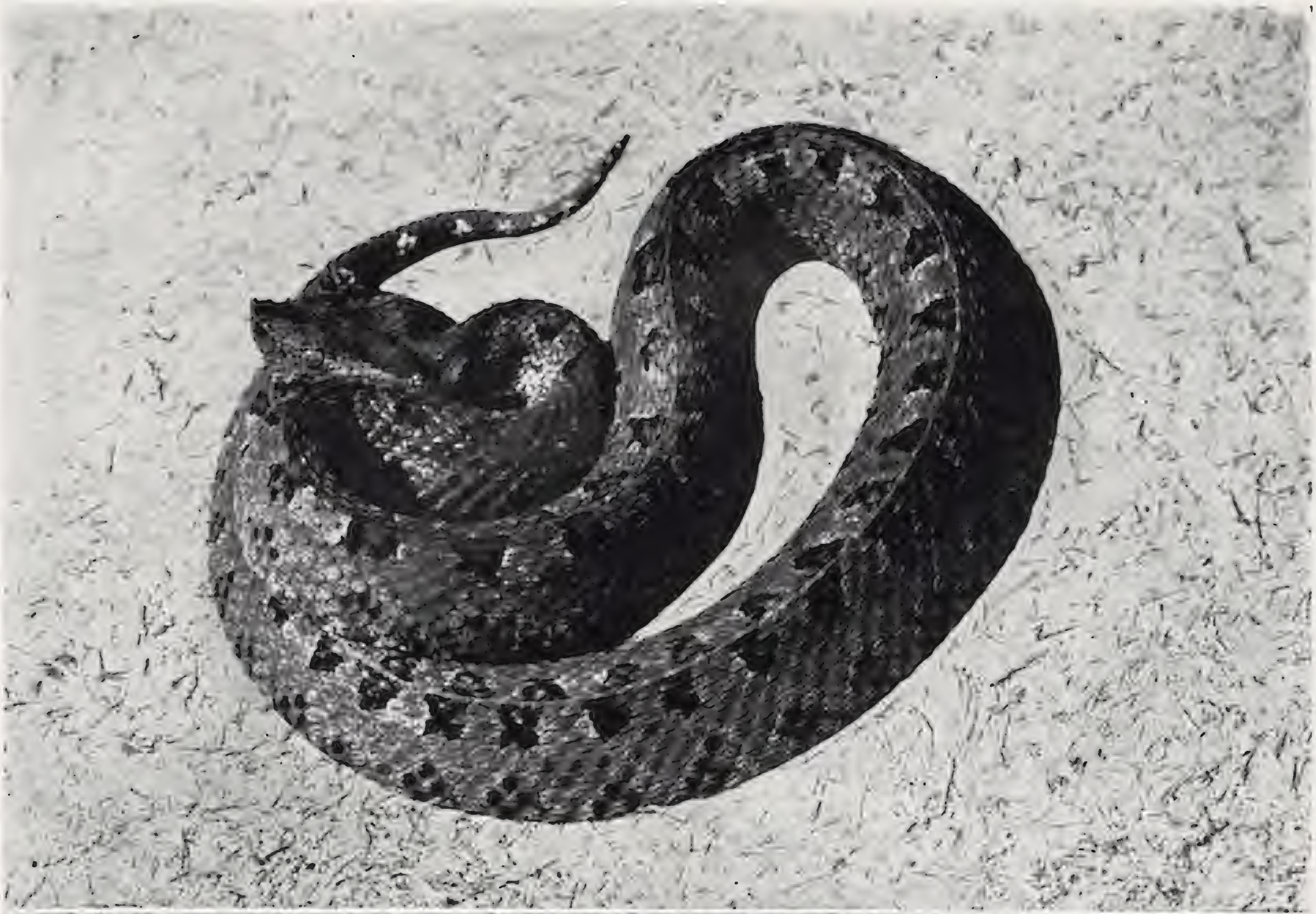
Fig. 19. Palm Vipers. The genus *Bothrops* forms the dominating group of venomous serpents in the New World tropics. It contains extremely dangerous species, including the fer-de-lance. The palm vipers are among its smaller members, and characteristic in being arboreal and having a prehensile tail. Their fangs are proportionately very long. Most of them are of greenish hues and difficult to detect amongst foliage. The examples shown represent March's Palm Viper. *Bothrops nigroviridis marchi*, of Honduras. Photograph by Anton Vestby.

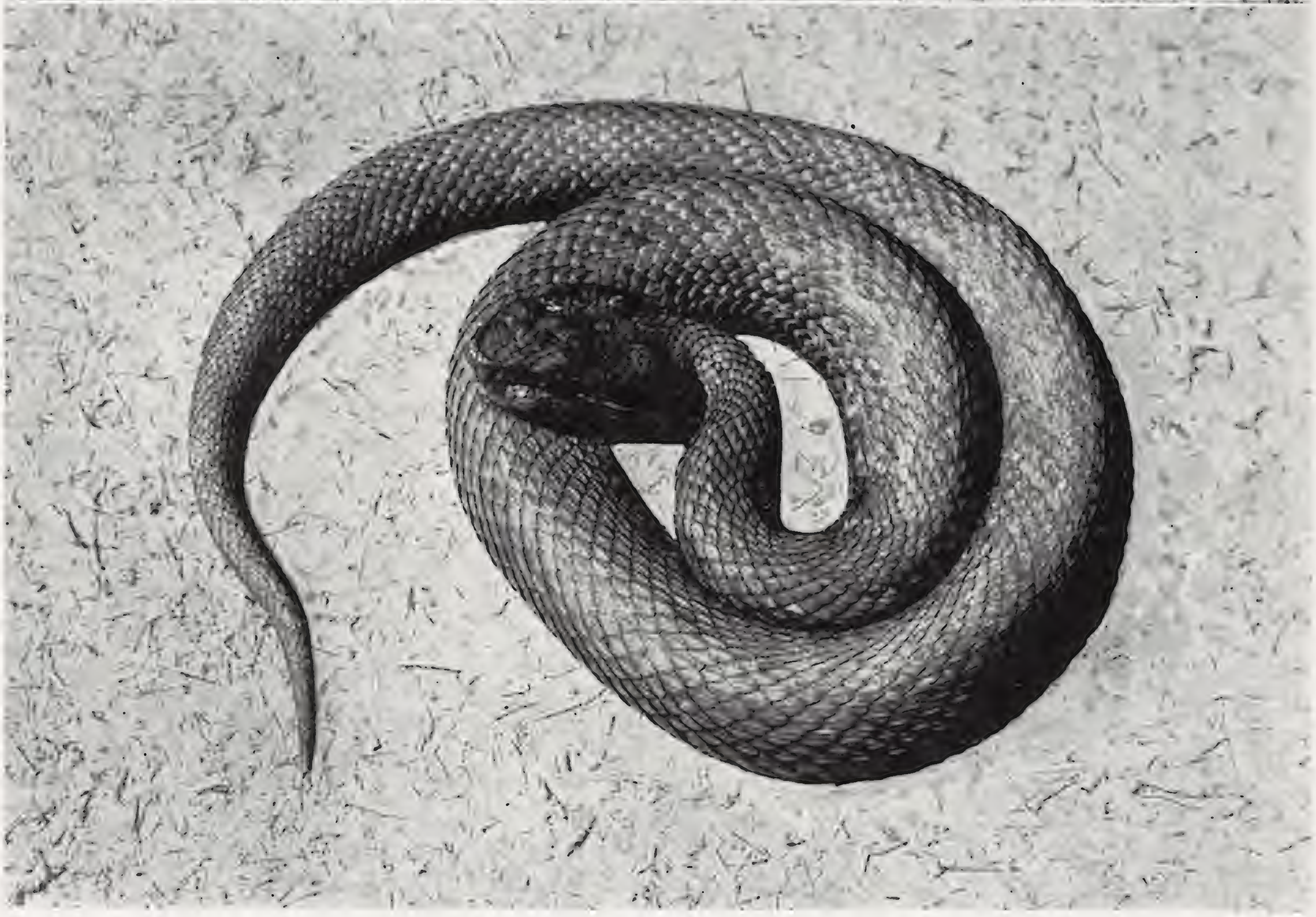




Upper—Fig. 20. March's Palm Viper, *Bothrops nigroviridis marchi.* The typical form occurs in Costa Rica and Nicaragua. Several fatal accidents occurred among a trail-cutting gang, owing to the difficulty in detecting these reptiles in the foliage.

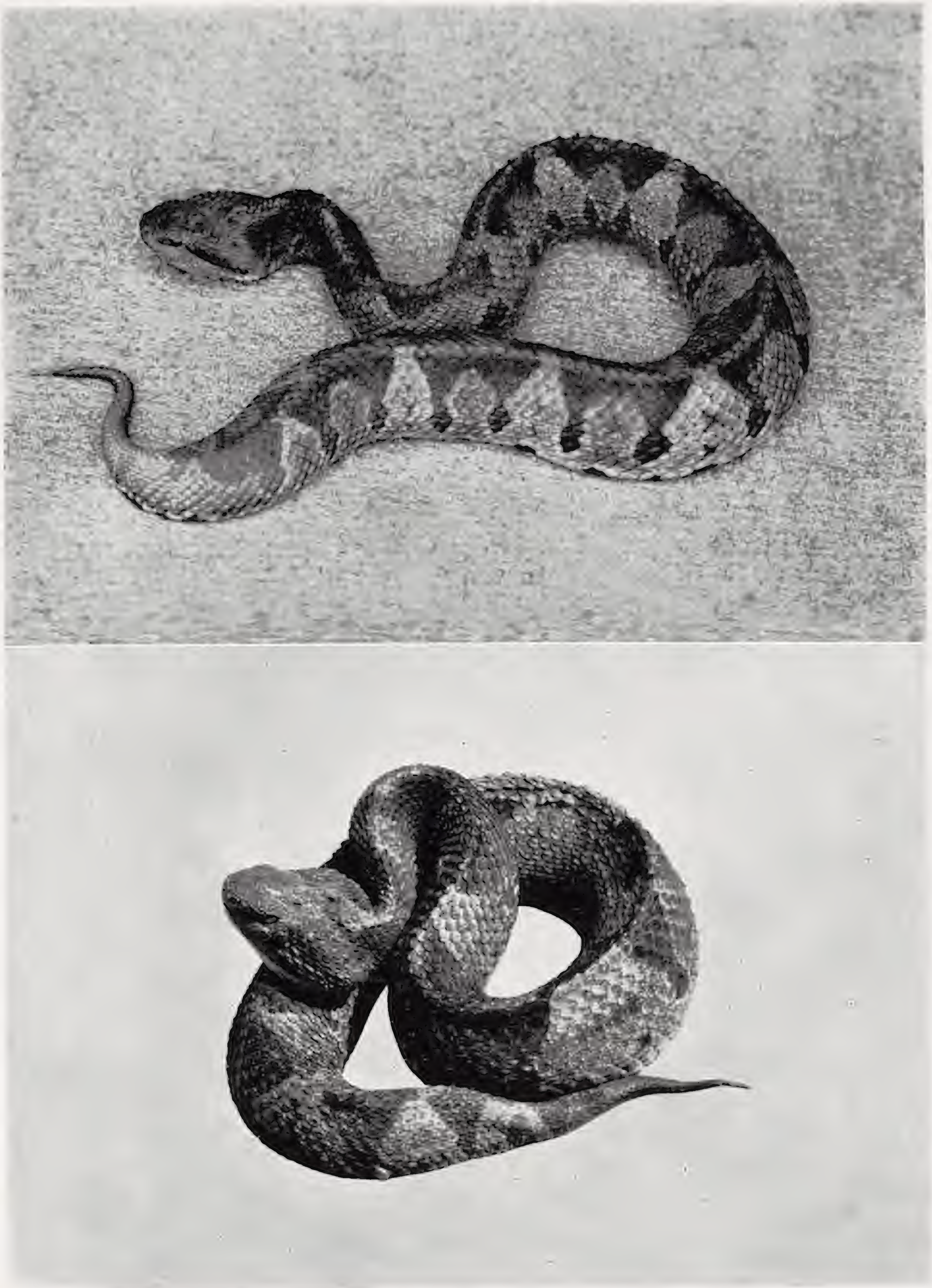
Lower—Fig. 21. Schlegel's Palm Viper, *Bothrops schlegelii* (yellow phase). This arboreal viper has a wide range, occurring from Guatemala into northern South America. There are two color phases, one lemon-yellow, the other dark green, blotched with red. Spiny scales stand erect over the eyes, which character has produced another name—the eye-lash viper. Photographs by Anton Vestby.



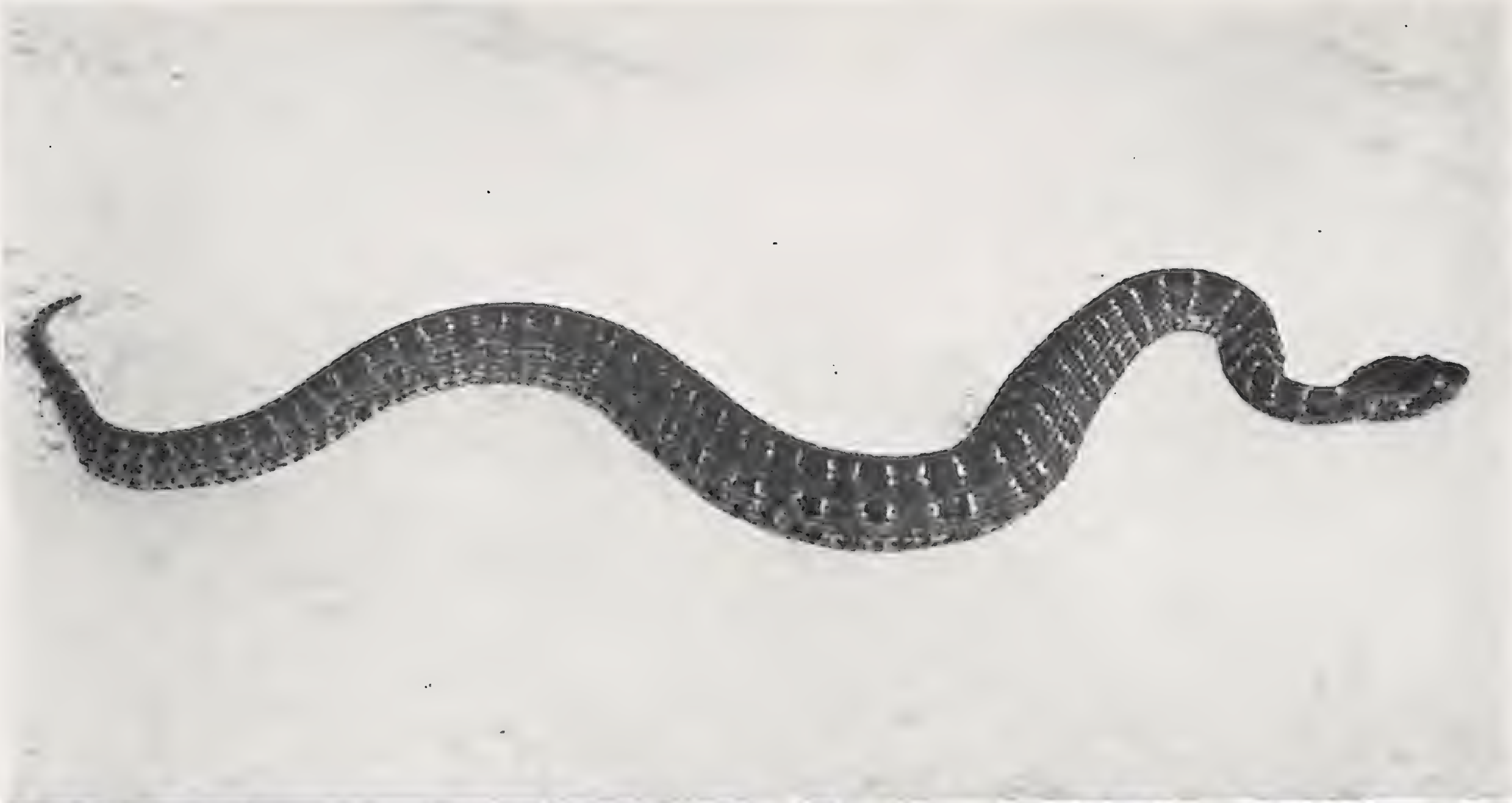


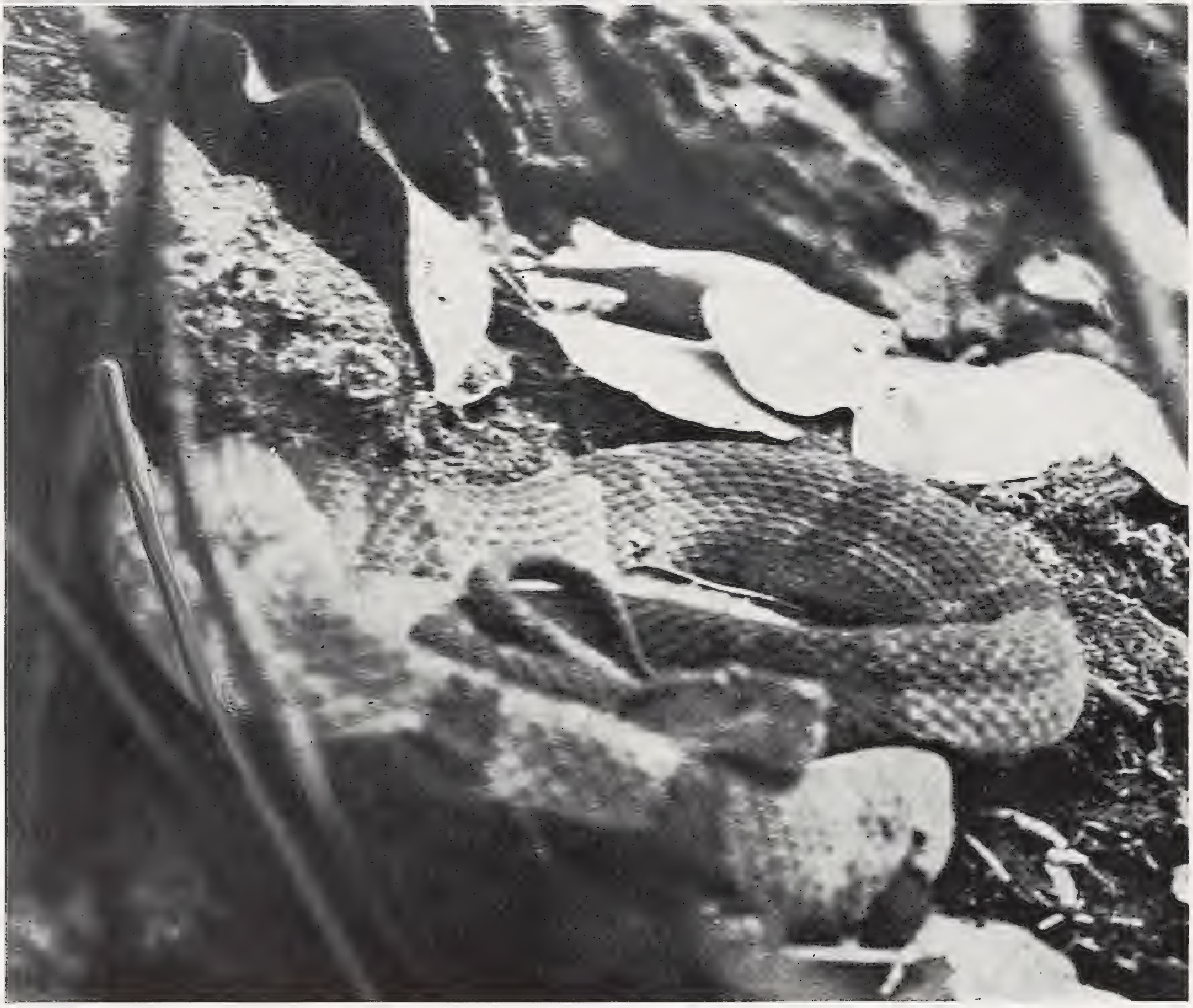
Upper—Fig. 22. Nose-horned Viper, *Bothrops nasuta*. Central America, Colombia and Ecuador. There is fair variety of small members of *Bothrops*. This common serpent is rated as one of the most active of its genus, and can lurch its coil a foot forward. It is sometimes called "jumping viper," but the term properly belongs to the particularly vigorous species shown on the following plate.

Lower—Fig. 23. Godman's Viper. *Bothrops godmani*, of Central America. Length is under twenty-four inches. Photographs by Anton Vestby.



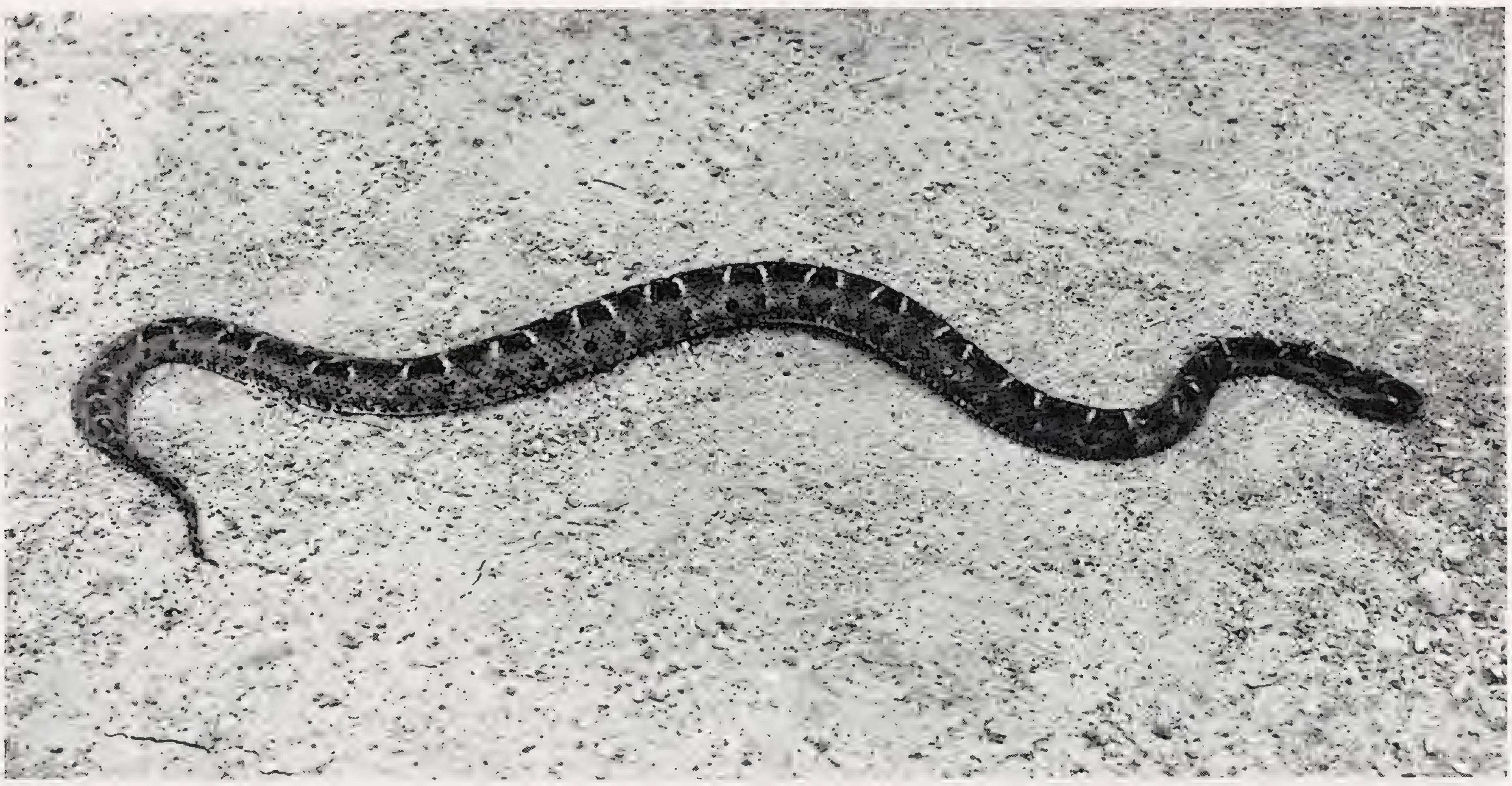
The Jumping Viper, *Bothrops nummifera.* (*Upper,* Fig. 24 and *Lower,* Fig. 25.) This Central American species is less than a yard in length, but grotesque in being the proportionately stoutest viper of the American tropics. It is also the most vigorous in biting, as it makes a striking jump when irritated, that may carry the whole body a full two feet forward, or to a greater distance if the snake strikes from the side of a log or bank where there is purchase to lurch its coils. The upper figure shows a young example with particularly bright pattern. Photographs by Anton Vestby.

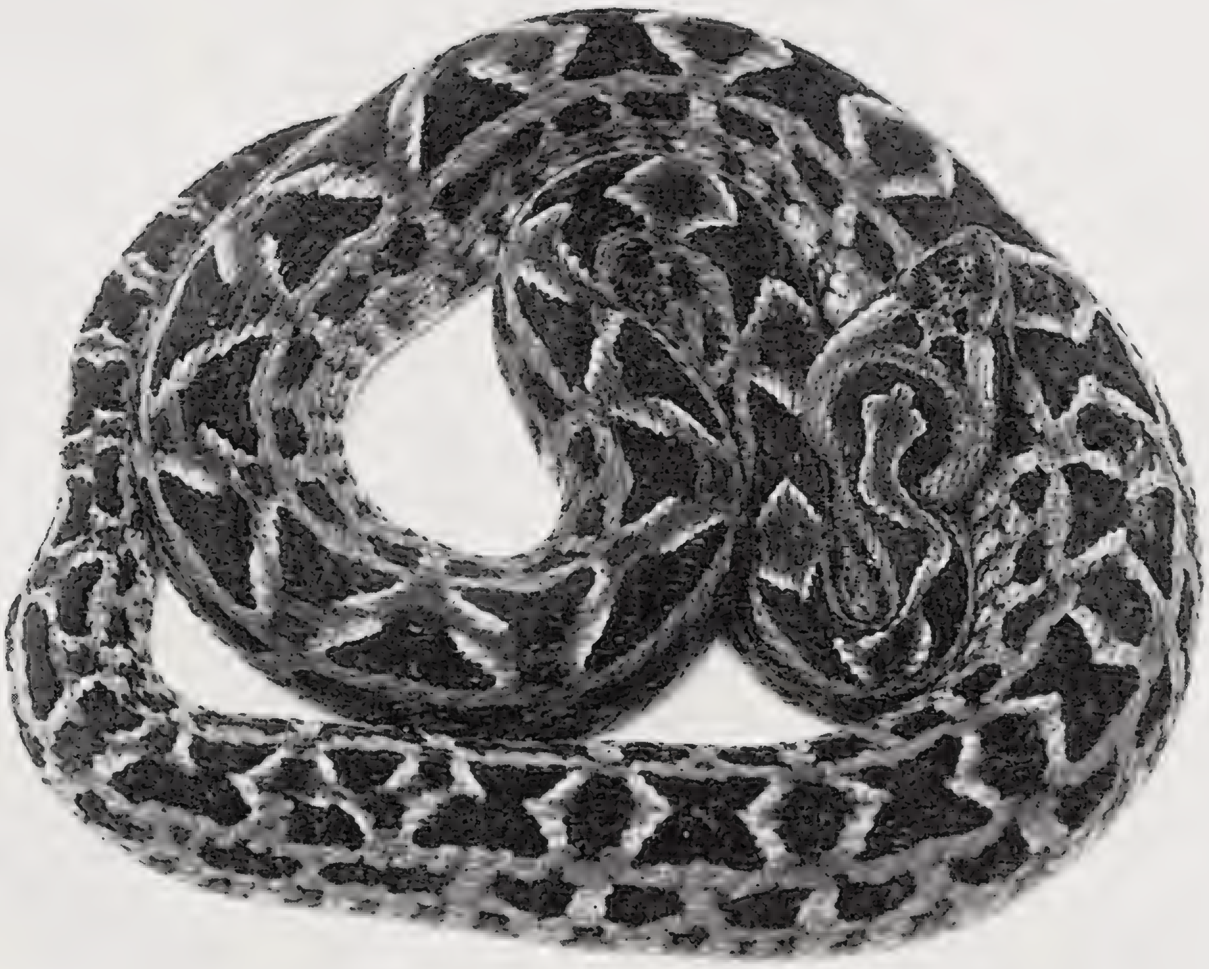




Upper—Fig. 26. Cotiarinha, *Bothrops itapetiningæ*. A small, brownish viper of southern Brazil. It is rather rare.

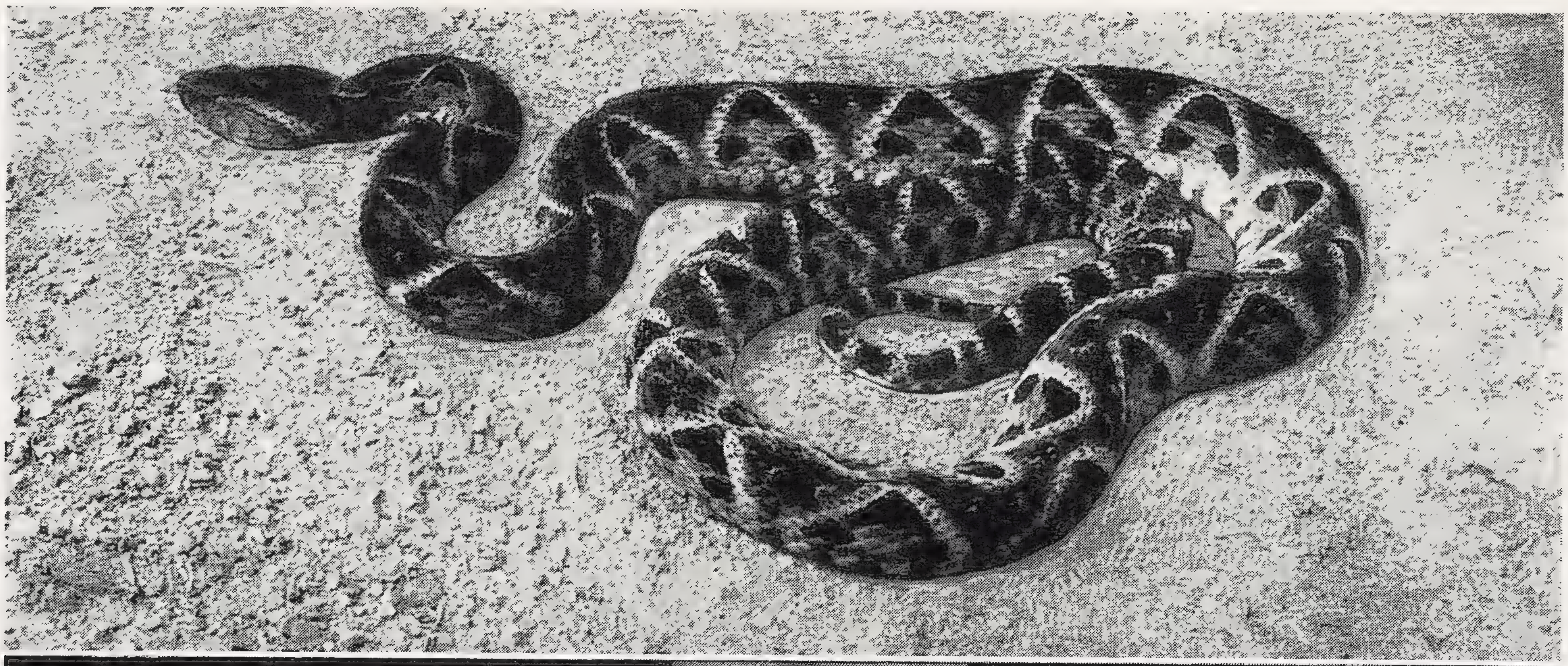
Lower—Fig. 27. The Island Tree Viper, *Bothrops insularis*. Unique among South American serpents in restricted *habitat*. Occurs on an island of less than a square mile of surface, about forty miles from Santos, Brazil. Feeding entirely upon birds and requiring an exceptionally active poison to kill such elusive prey, this serpent is rated as the most poisonous of its genus. Photograph courtesy of Dr. Afranio do Amaral.

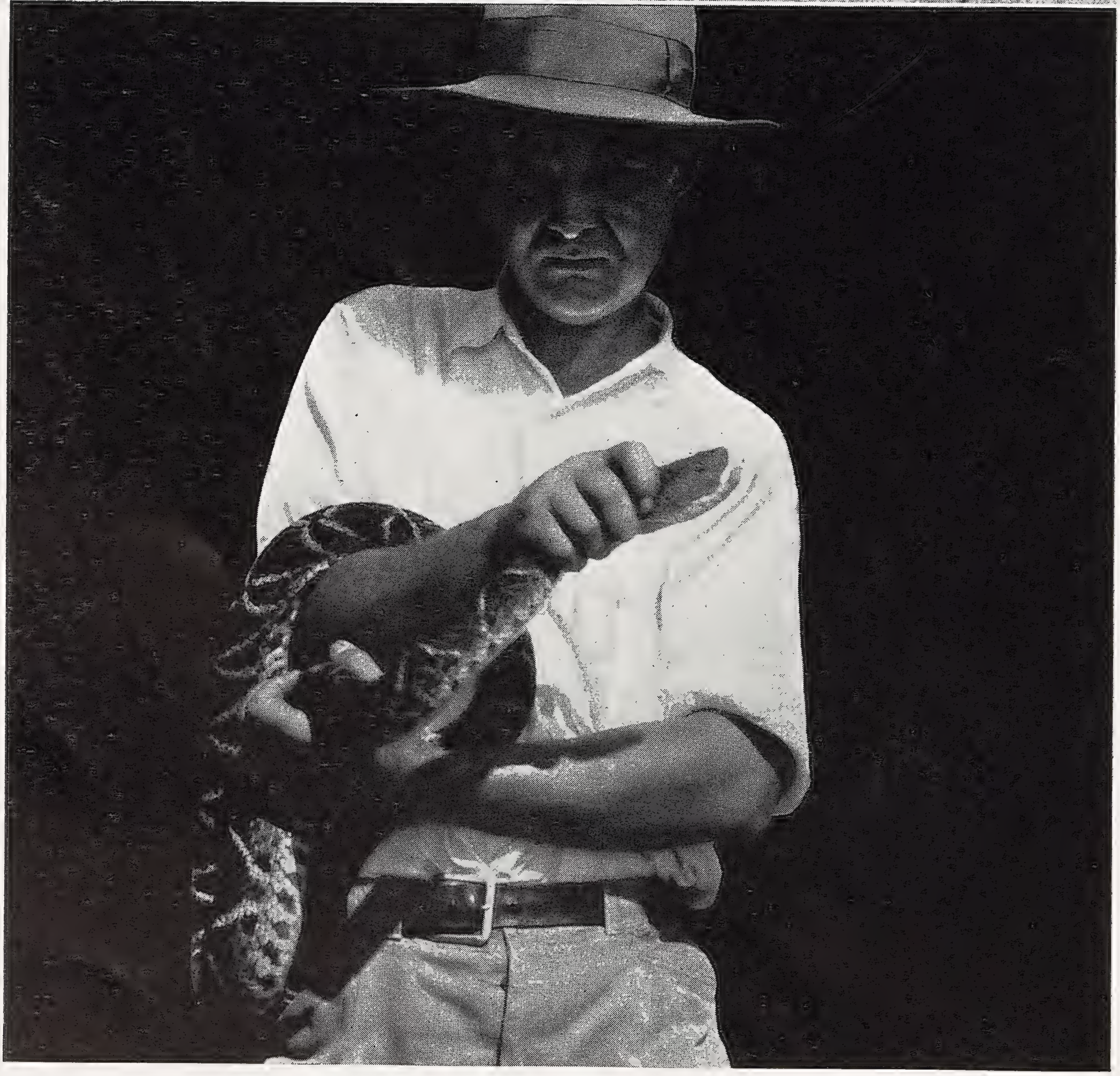




Upper—Fig. 28. Maximilian's Viper, *Bothrops neuwiedii.* One of the most widespread of the South American pit vipers. It rather closely resembles the fer-de-lance in form and habits, being irritable and quick to strike. Photograph courtesy of Dr. Afranio do Amaral.

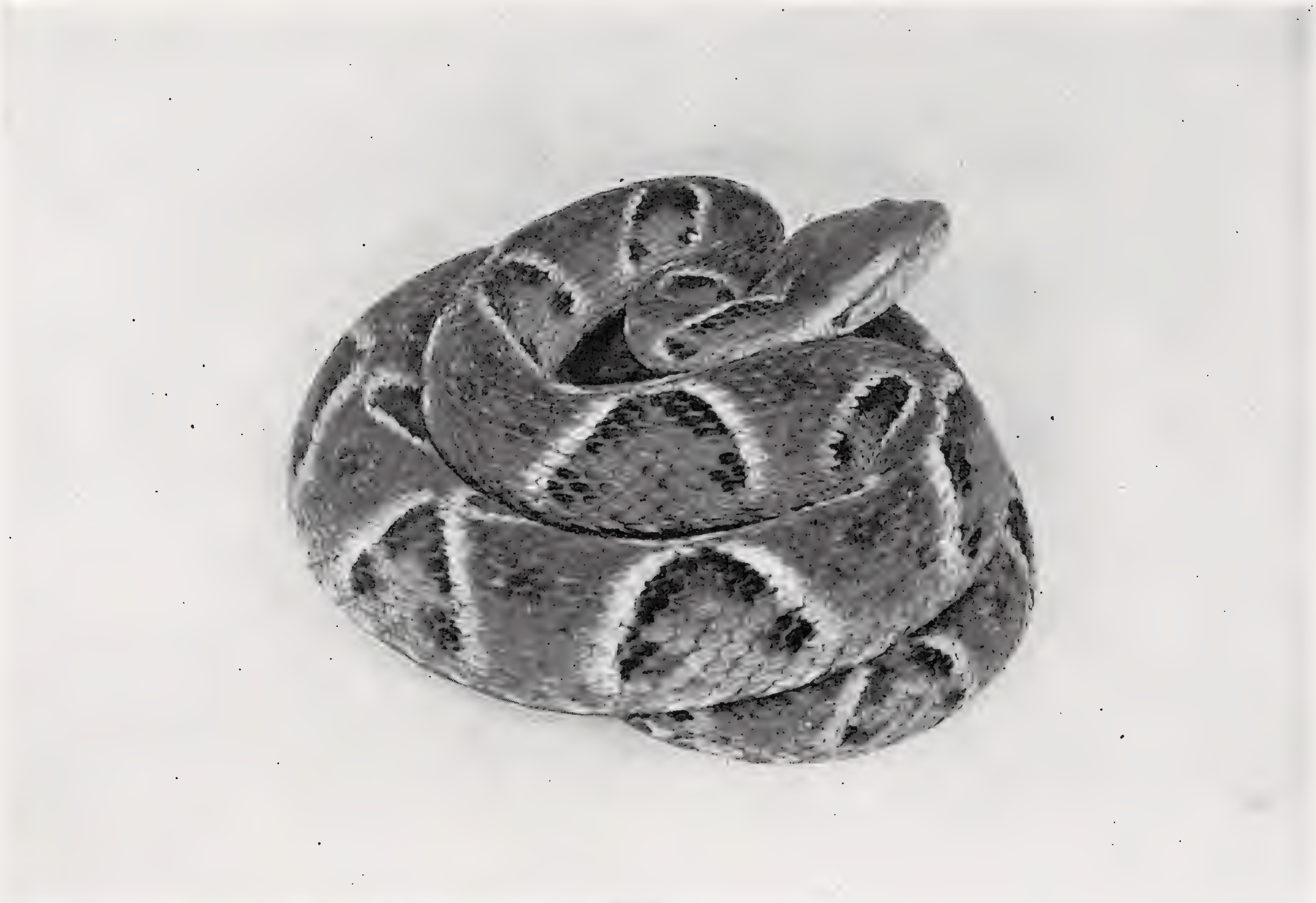
Lower—Fig. 29. Maximilian's Viper, *Bothrops neuwiedii* (variety). Several distinct subspecies have been named. The blotches may be more closely crowded, or more vivid, owing to a paler body hue.

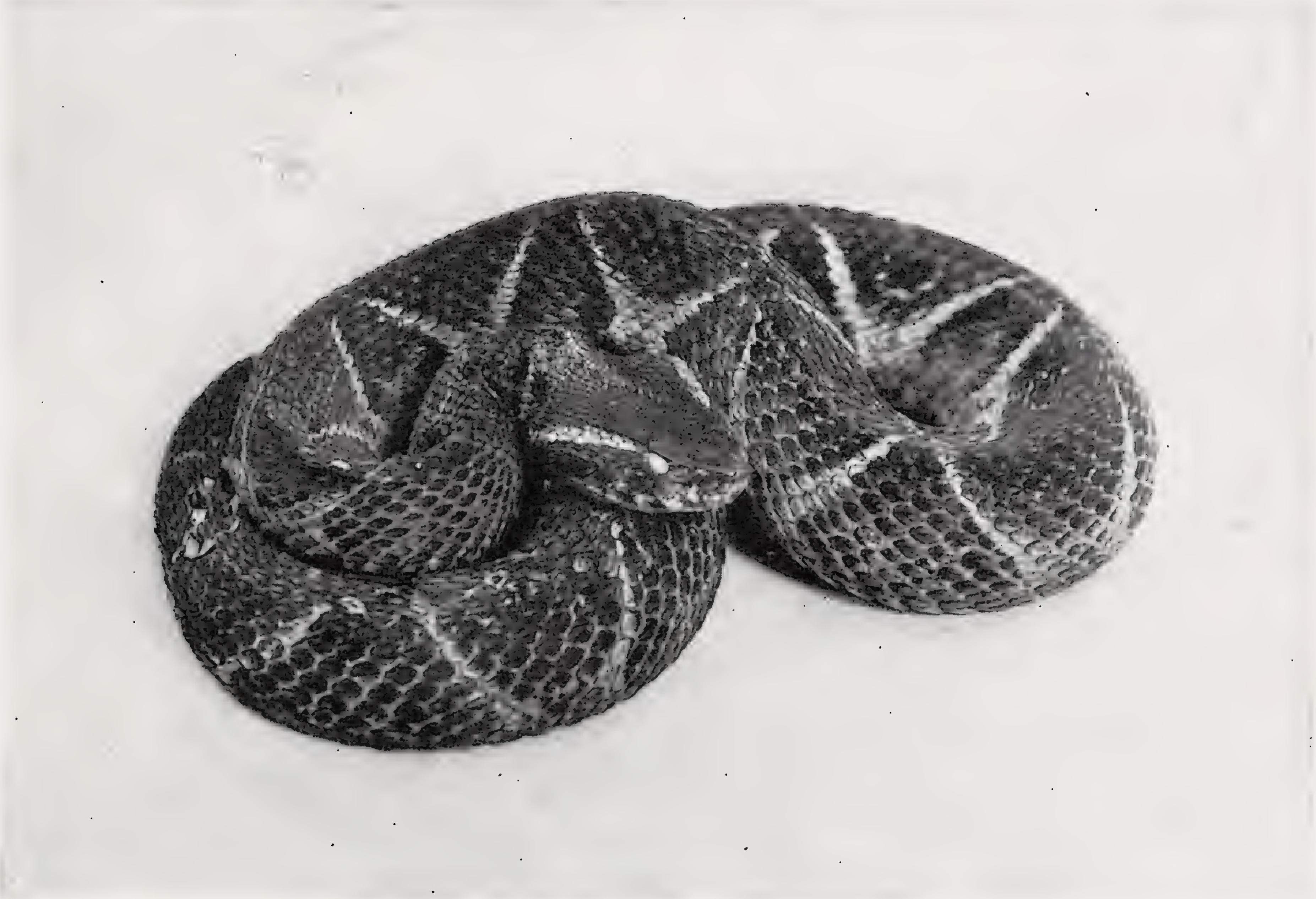




Upper—Fig. 30. Fer-de-lance, *Bothrops atrox.* The familiar common name originated among the Creole-French on the islands of Martinique and St. Lucia, where this serpent was once abundant but is now rare. In Central America it is known as "Barba amarilla" and in Brazil most commonly as "Jararaca."

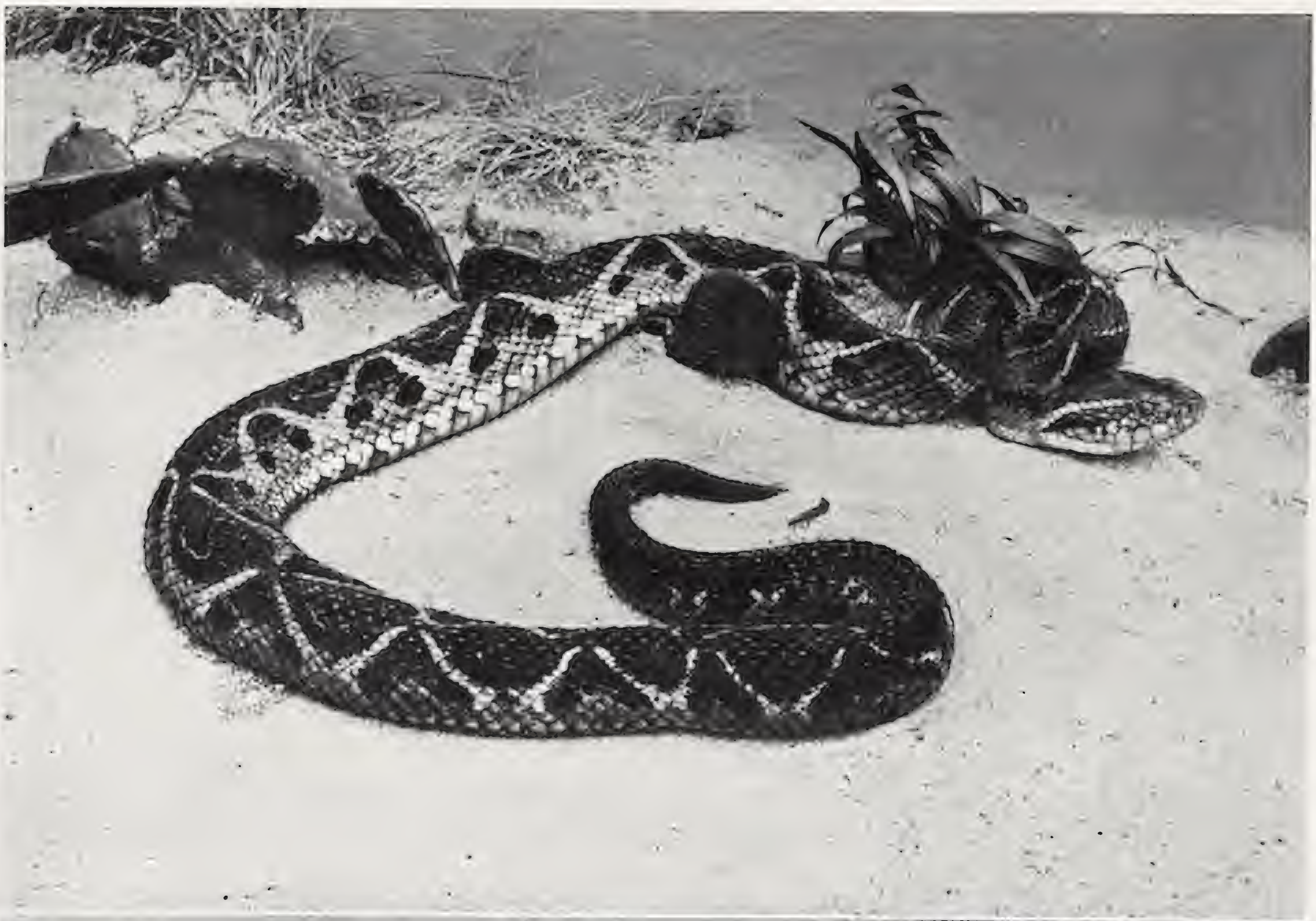
Lower—Fig. 31. A big specimen of barba amarilla or fer-de-lance, captured near Tela, Honduras. The exact length was eight feet and four inches. Photographs by Anton Vestby.

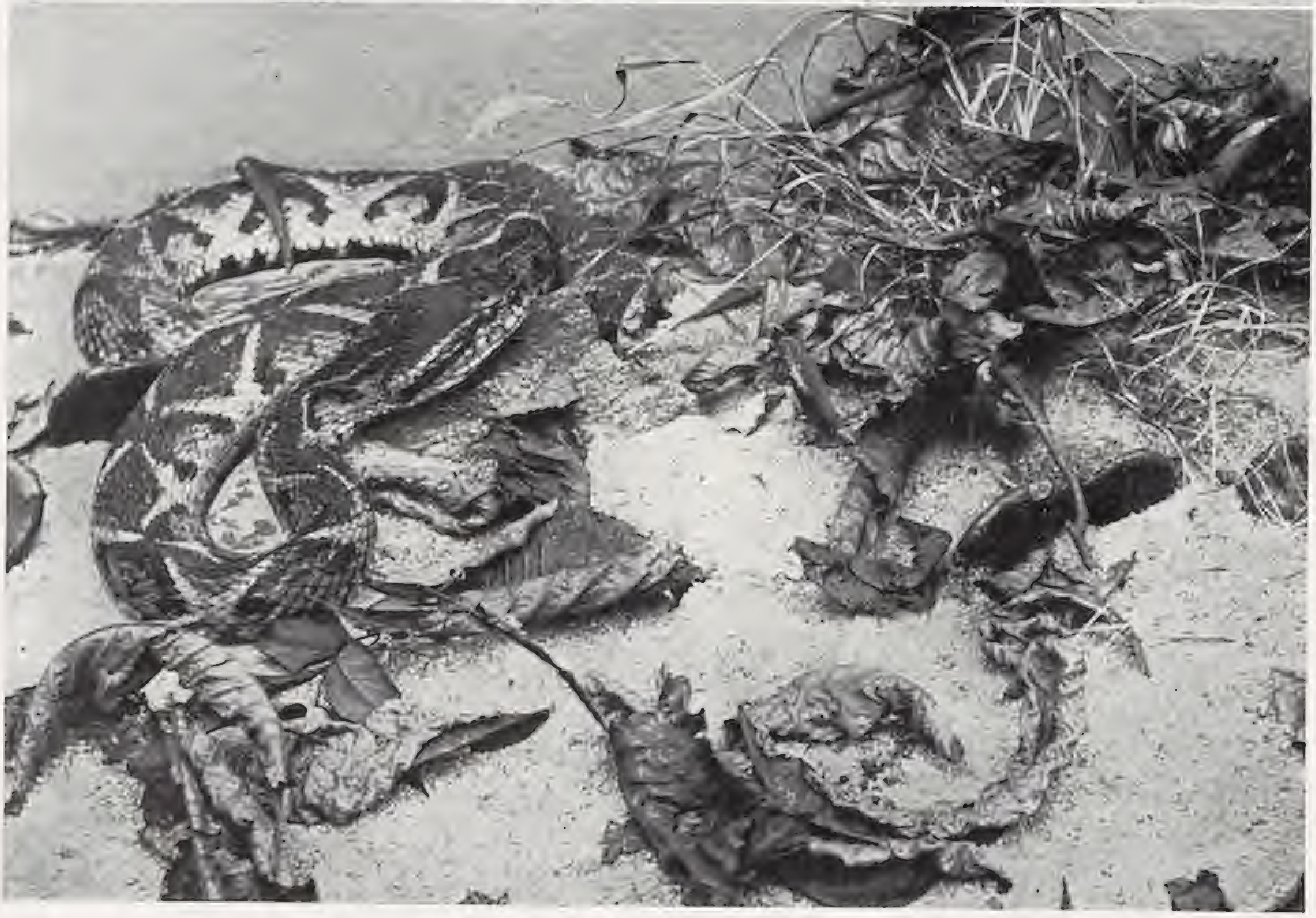




Upper—Fig. 32. Fer-de-lance or Jararaca. (Note Fig. 30.) The most commonly seen venomous serpent in the American tropics. There is considerable variation in the pattern and body hue. The latter is more frequently gray or greenish-gray, with darker, pale-edged blotches.

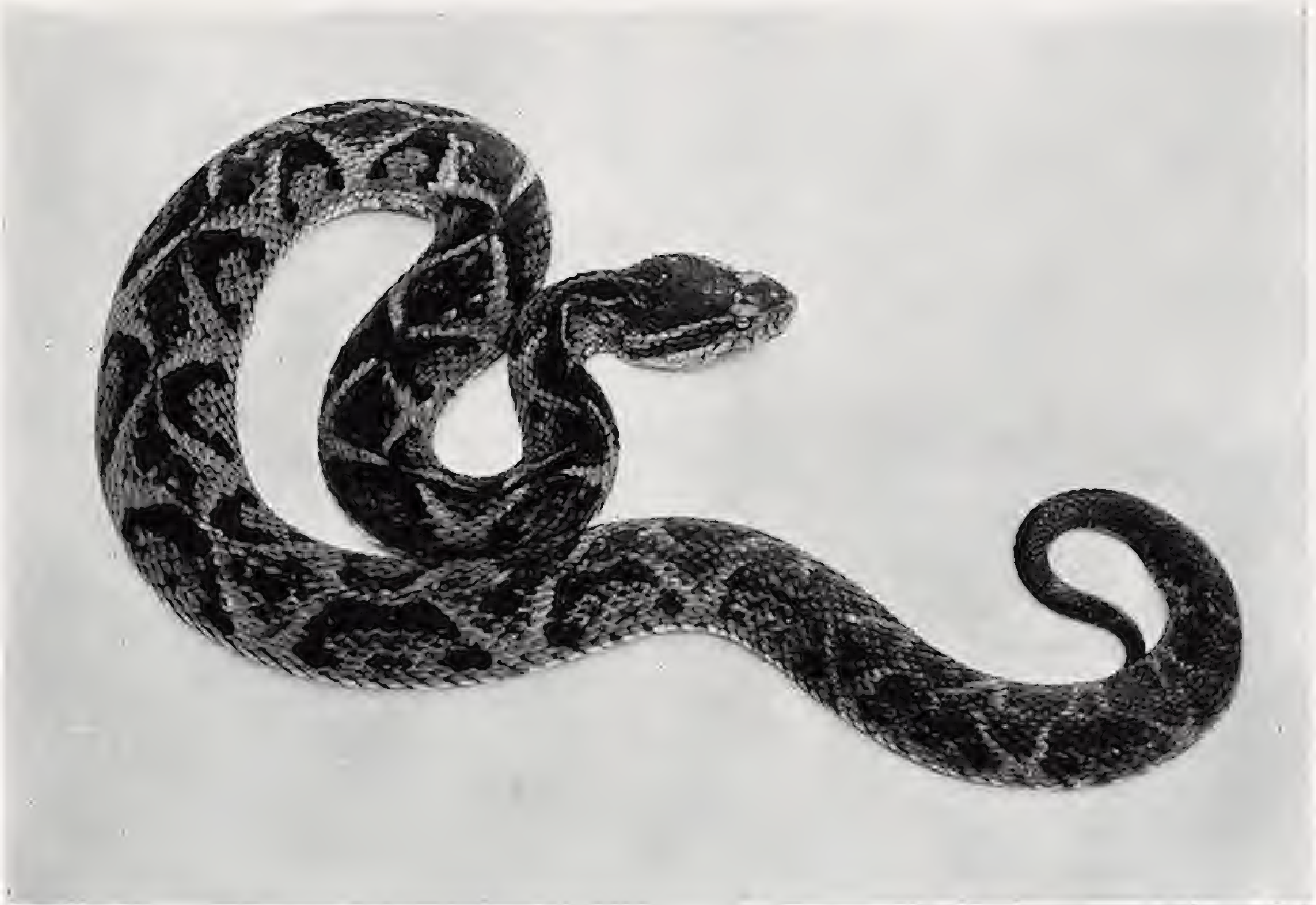
Lower—Fig. 33. Jararacucu, *Bothrops jararacussu*. Largely confined to southerly Brazil. It is a thicker-bodied serpent than the more widely distributed jararaca. (Note Figs. 34, 35 and 36.)

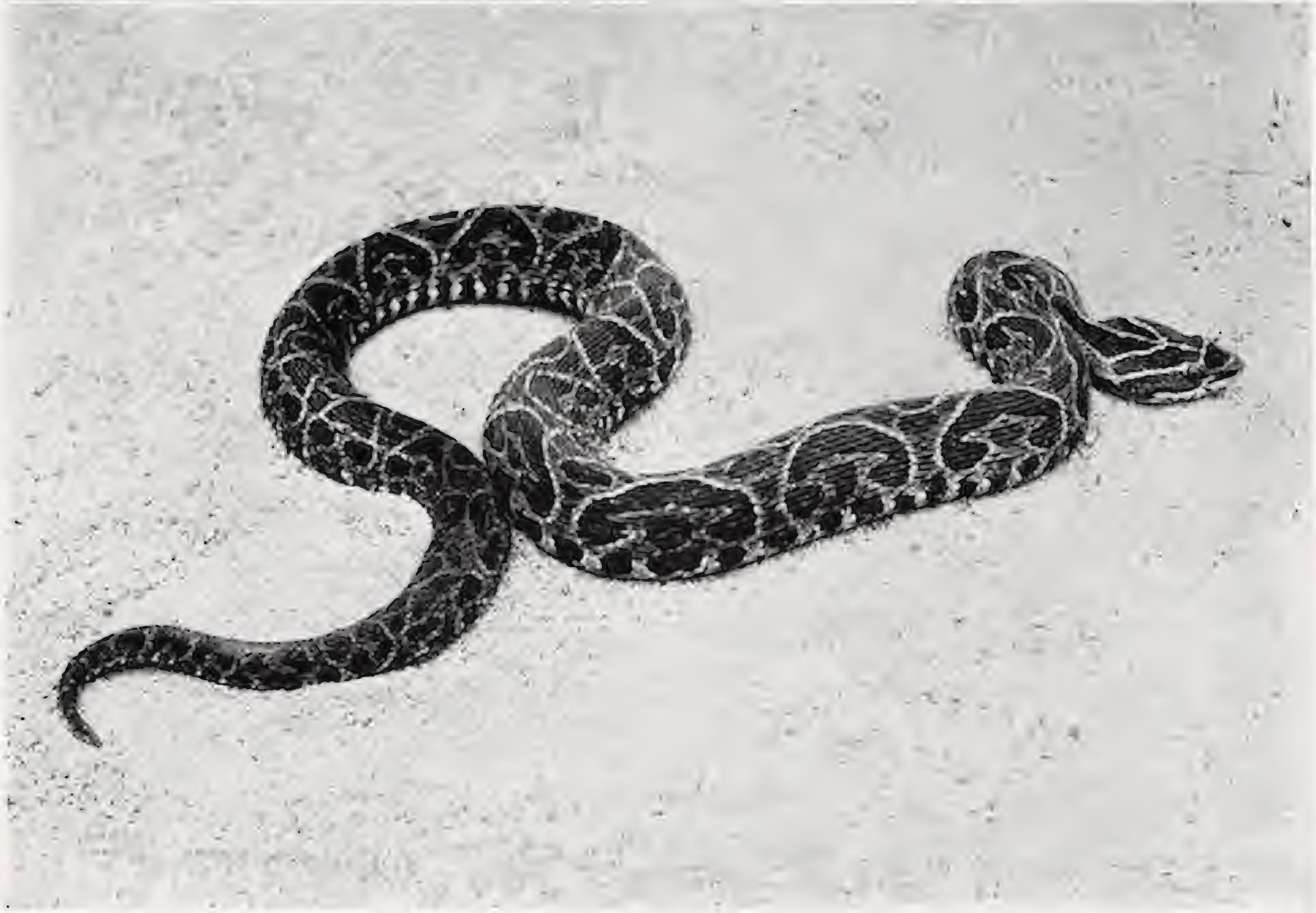




Upper—Fig. 34. Jararacucu, *Bothrops jararacussu*. While of the "fer-de-lance" type and similar on gross examination, the markings are more angular and the paler margins of the blotches dominate the pattern.

Lower—Fig. 35. Jararacucu. Gray-green or olive hues, splashed with yellow and darker blotches, form dangerously deceptive patterns when these creatures are lurking in low vegetation. They fortunately have a habit of warning of their presence by vibrating the tail, which produces a sharp, buzzing sound among the leaves.





Upper—Fig. 36. Jararacucu, *Bothrops jararacussu*. Showing the pattern viewed from above. (Note Figs. 33, 34 and 35.)

Lower—Fig. 37. Urutu, *Bothrops alternatus*. Southerly Brazil, Paraguay, Argentina and Uruguay. The most handsomely marked member of the *Bothrops* genus. The crescents are chocolate-brown, edged with white or yellow. It attains a length of five feet and is quite heavy of body.

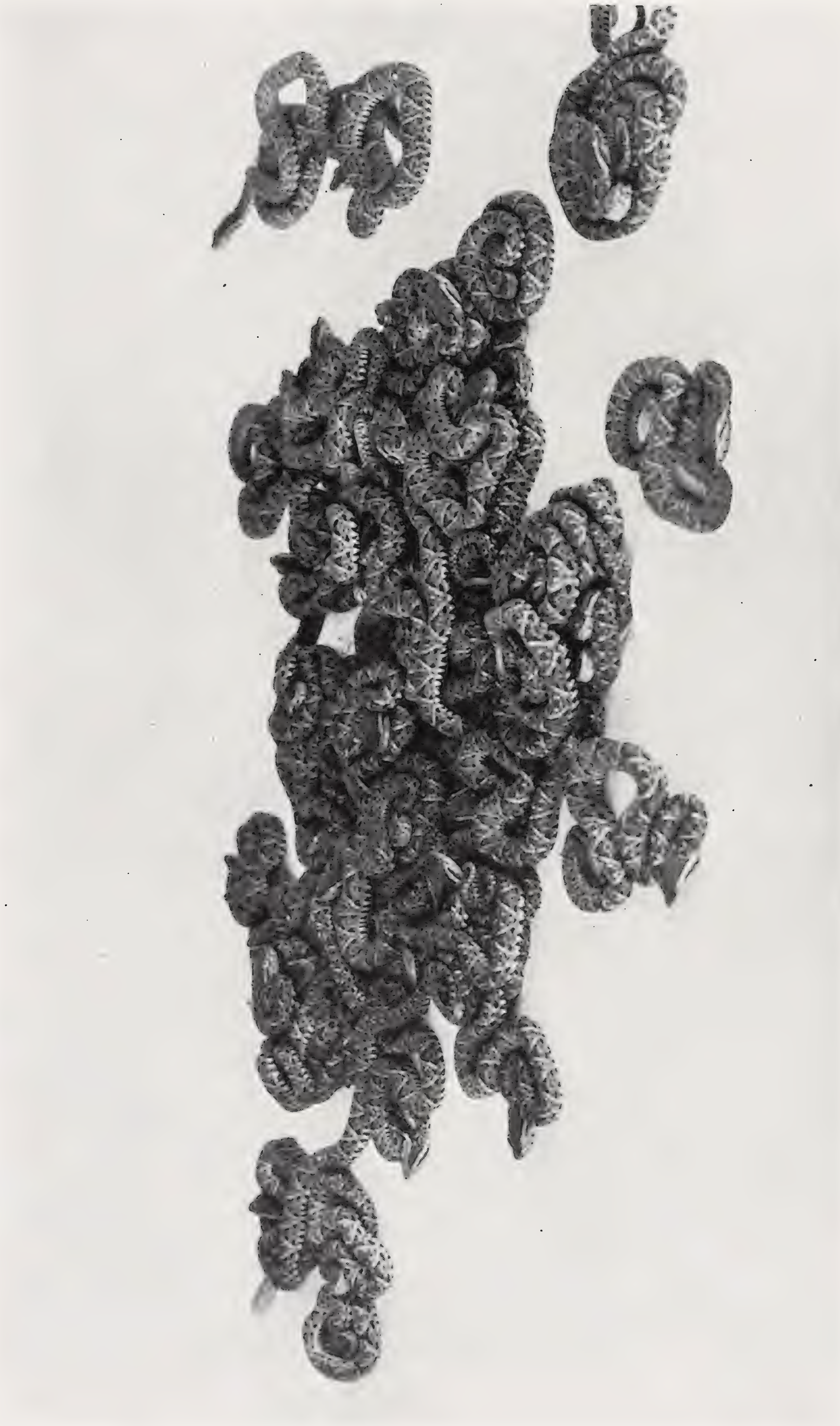


Fig. 38. A Day-old Litter of Fer-de-lance.

There are over fifty infant serpents here, from one mother. With the exception of the bushmaster, the American vipers produce the young alive. The reason for the abundance of the fer-de-lance is the large number of progeny. The litters of three Honduran specimens were 64, 65 and 71. The young from a six-foot mother were twelve inches long. They are born fully provided with fangs. Photograph by Anton Vestby.

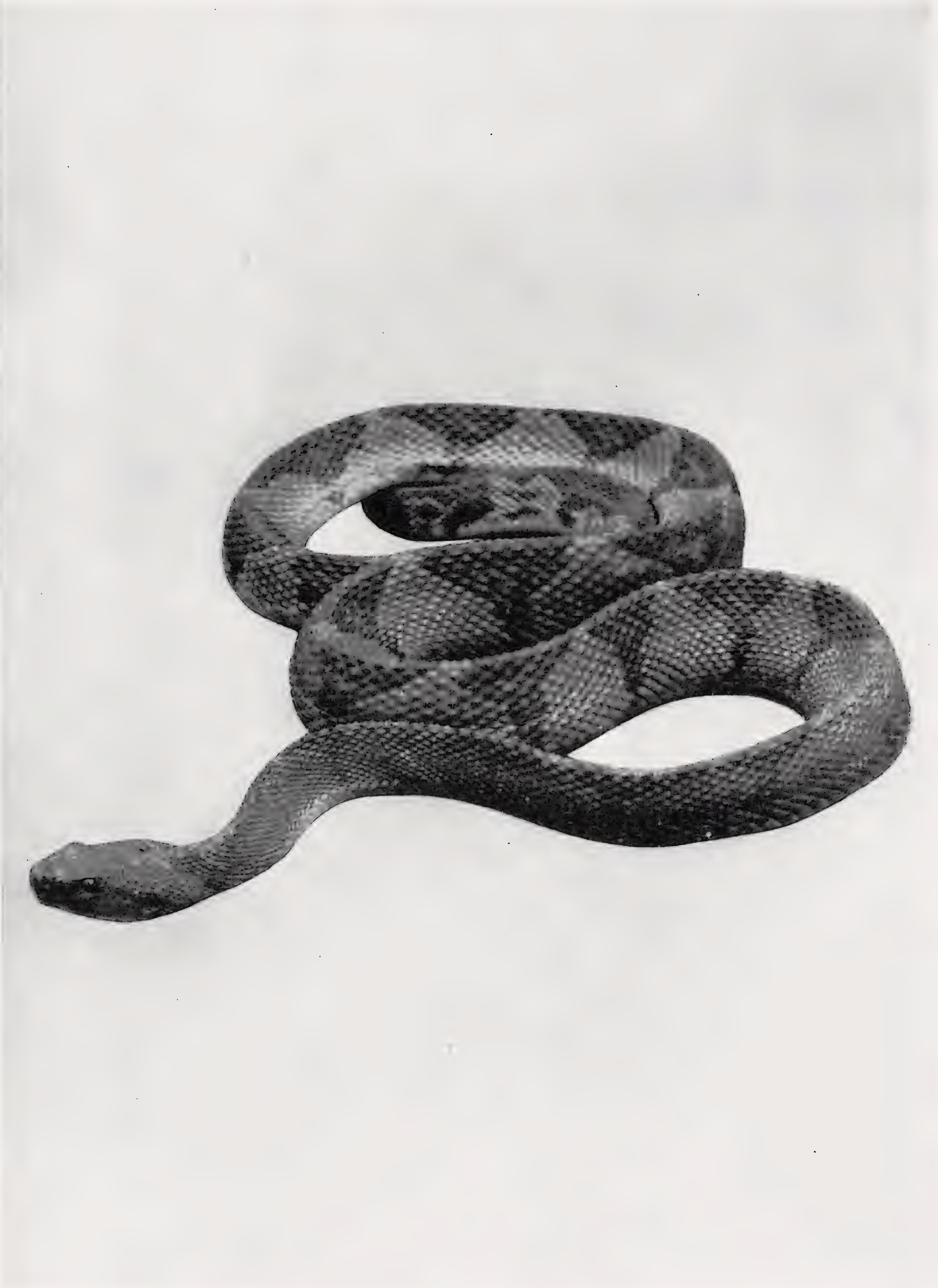
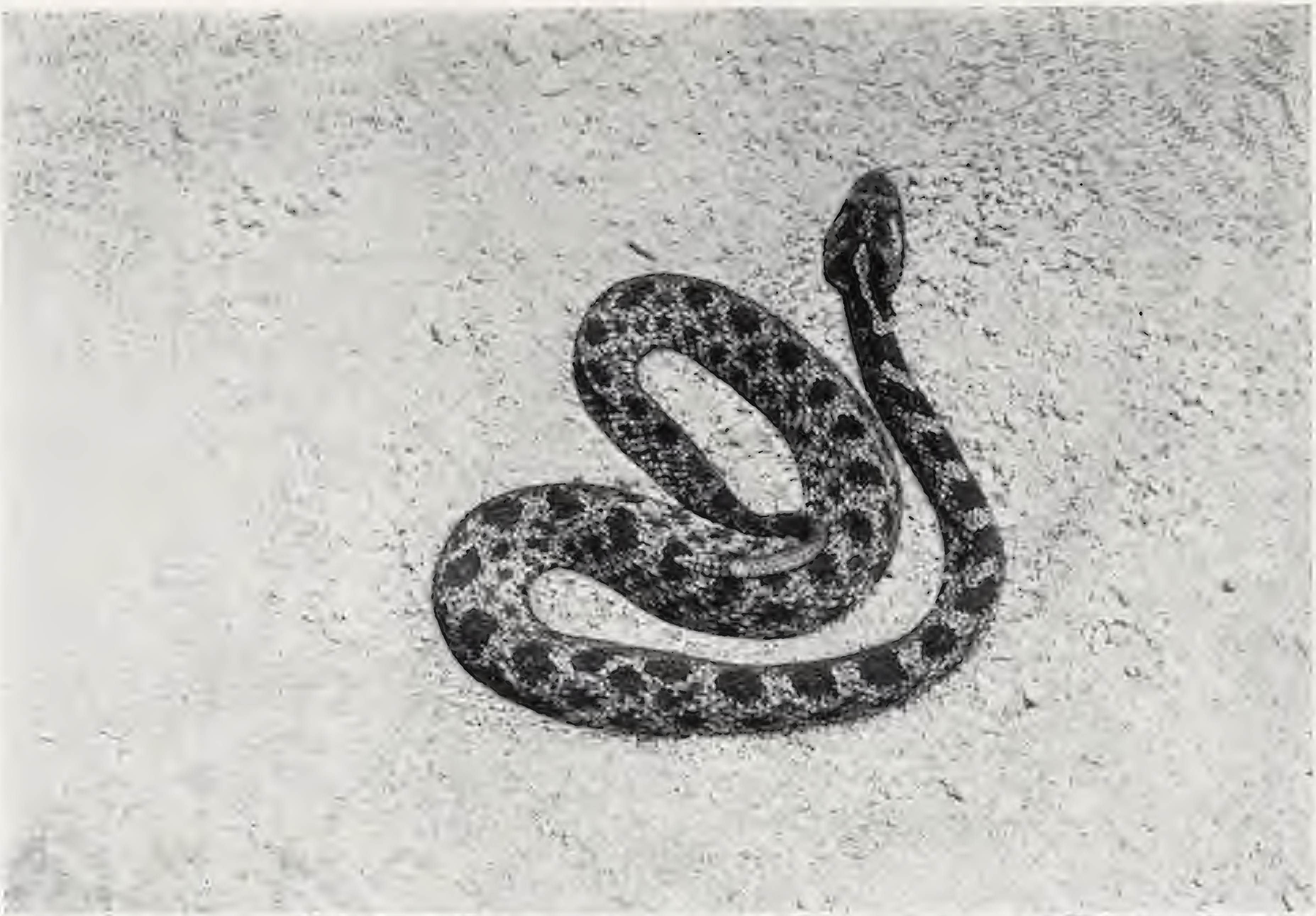
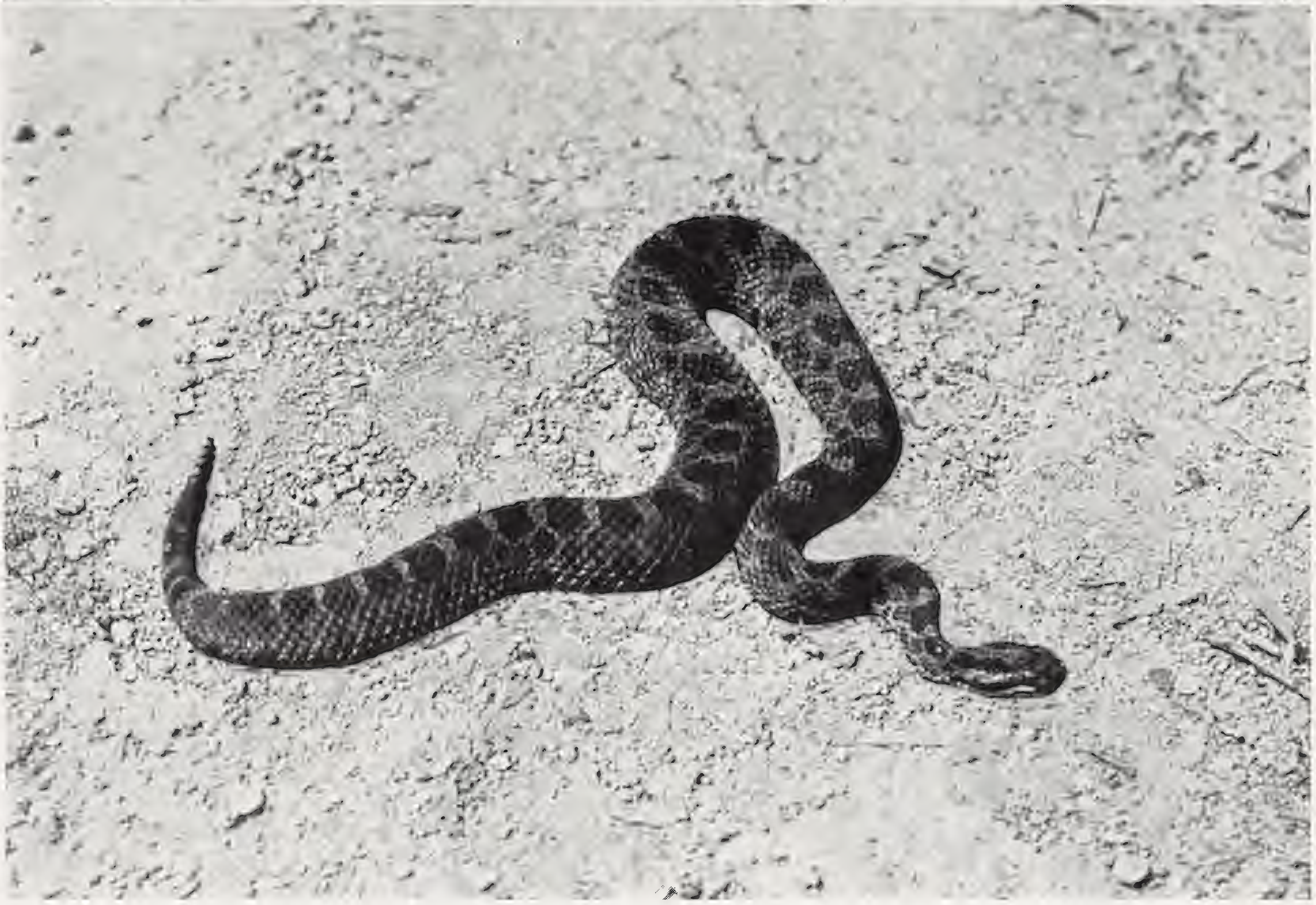


Fig. 39. The Bushmaster; Surucucu, *Lachesis muta*. Attaining a length of twelve feet, this is the largest of the world's viperine serpents. Its range is southern Central America and tropical South America. The scales are very rough and protruding; the coloration ruddy brown or salmon hue, with black cross-bands. The latter reverse the pattern of the fer-de-lance group, being wide on the back and narrowing on the sides. (See Fig. 1.)





Upper—Fig. 40. Pygmy Rattlesnake, *Sistrurus miliarius.* Southeastern United States. The rattlesnakes of North America vary from this eighteen-inch species to the big diamond-backs of six to eight feet. Note the minute rattle, which can be scarcely heard a few feet away.

Lower—Fig. 41. Massasauga, *Sistrurus catenatus.* This small brownish or grayish species occurs from western New York throughout the central states. It usually frequents swampy places.

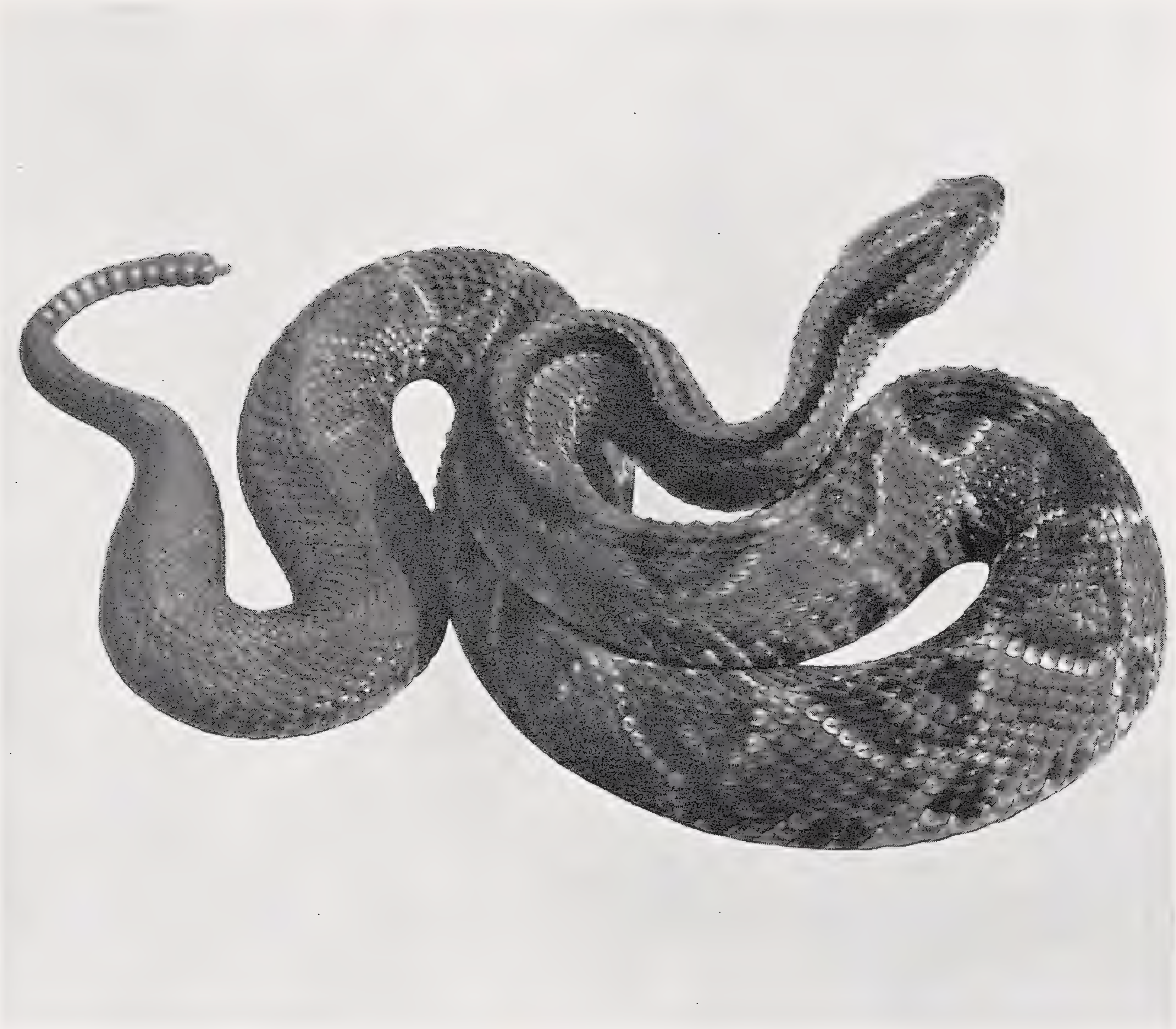
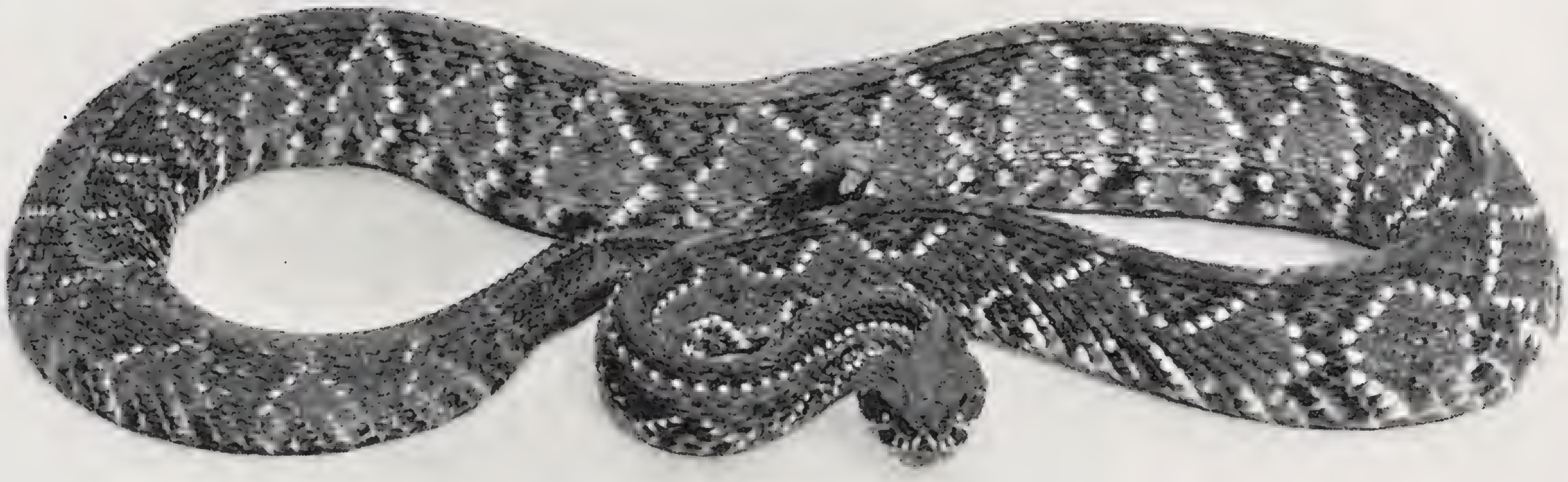
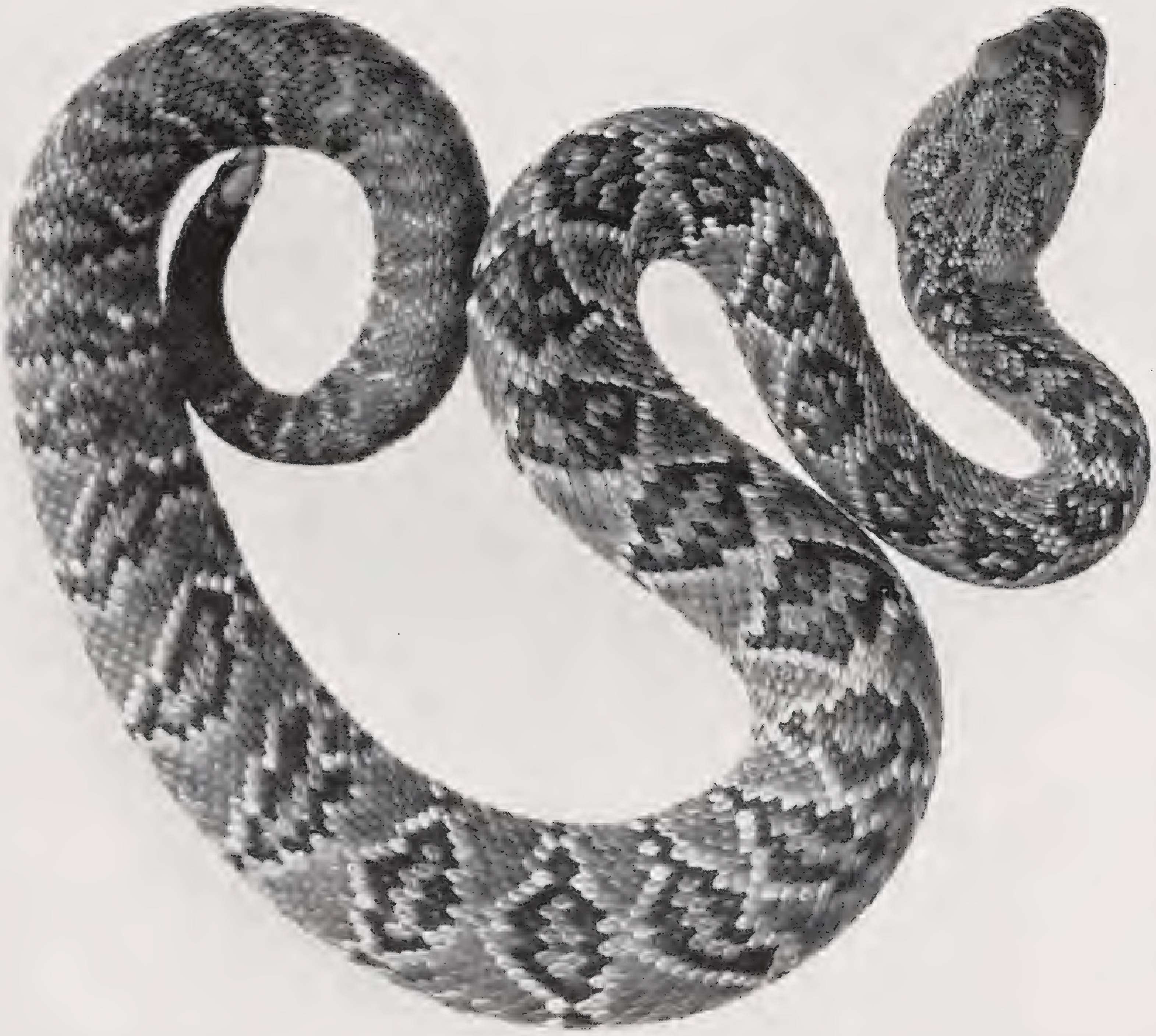


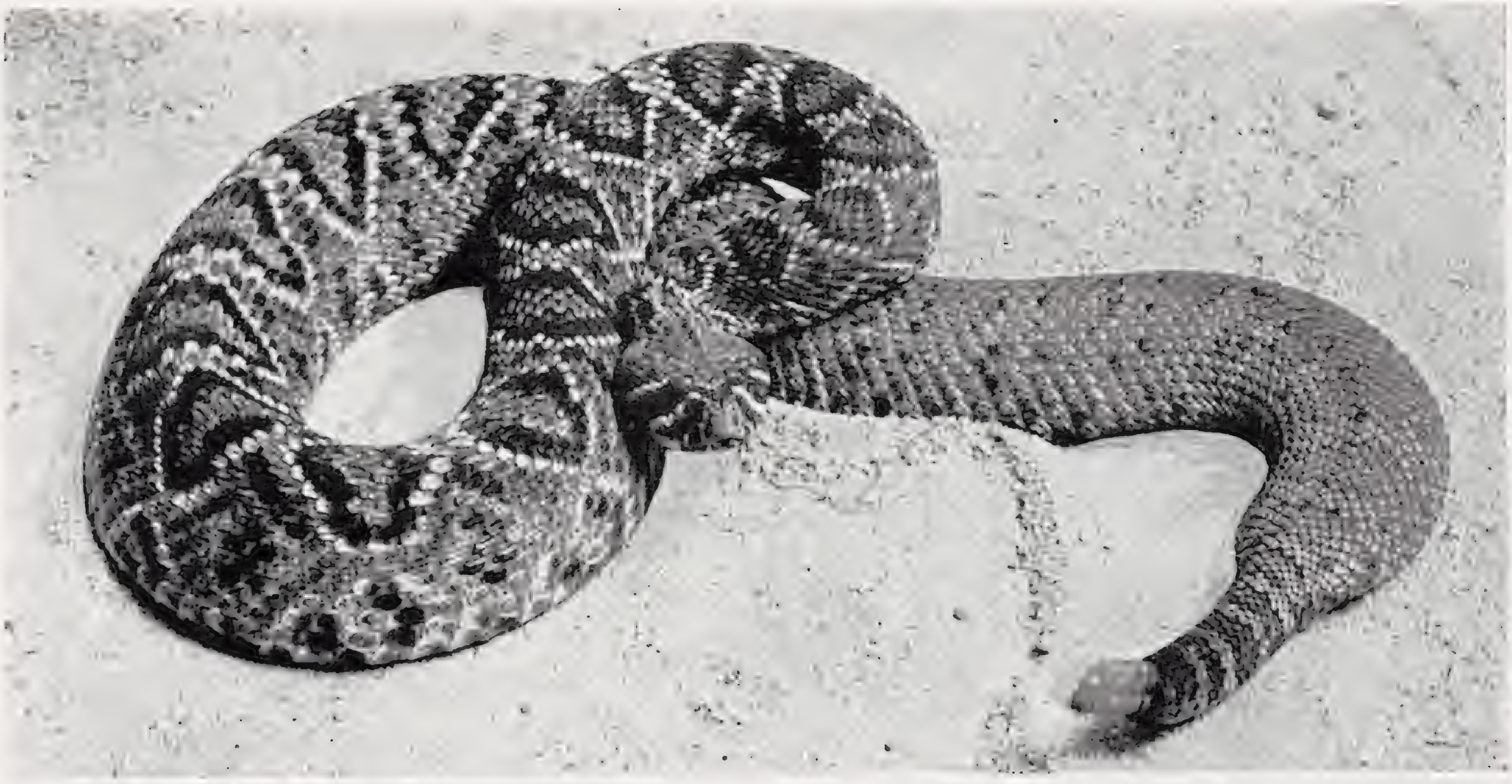
Fig. 42. The Tropical Rattlesnake; Cascabel (Spanish); Cascavel (Portuguese), *Crotalus terrificus durissus.* The most poisonous of the rattlers as well as the most savage. The venom differs from northern rattlesnakes and other New World vipers in having a largely neurotoxic action and in being nearly colorless. The venom of this serpent, in fact, appears to be the most highly toxic of any New World viper, with the exception of the unique and isolated island viper, *Bothrops insularis,* found off the coast of Brazil. This rattlesnake has the widest range of any species of *Crotalus,* occuring from central Mexico to northern Argentina. It is the only known species of rattlesnake of Central and South America. Distribution follows the higher and drier areas and does not extend into the damp coastal country. There is thus but a slight overlapping of this serpent with the occurrence of the fer-de-lance, which prefers the low and more humid coastal regions. Photograph by Anton Vestby.

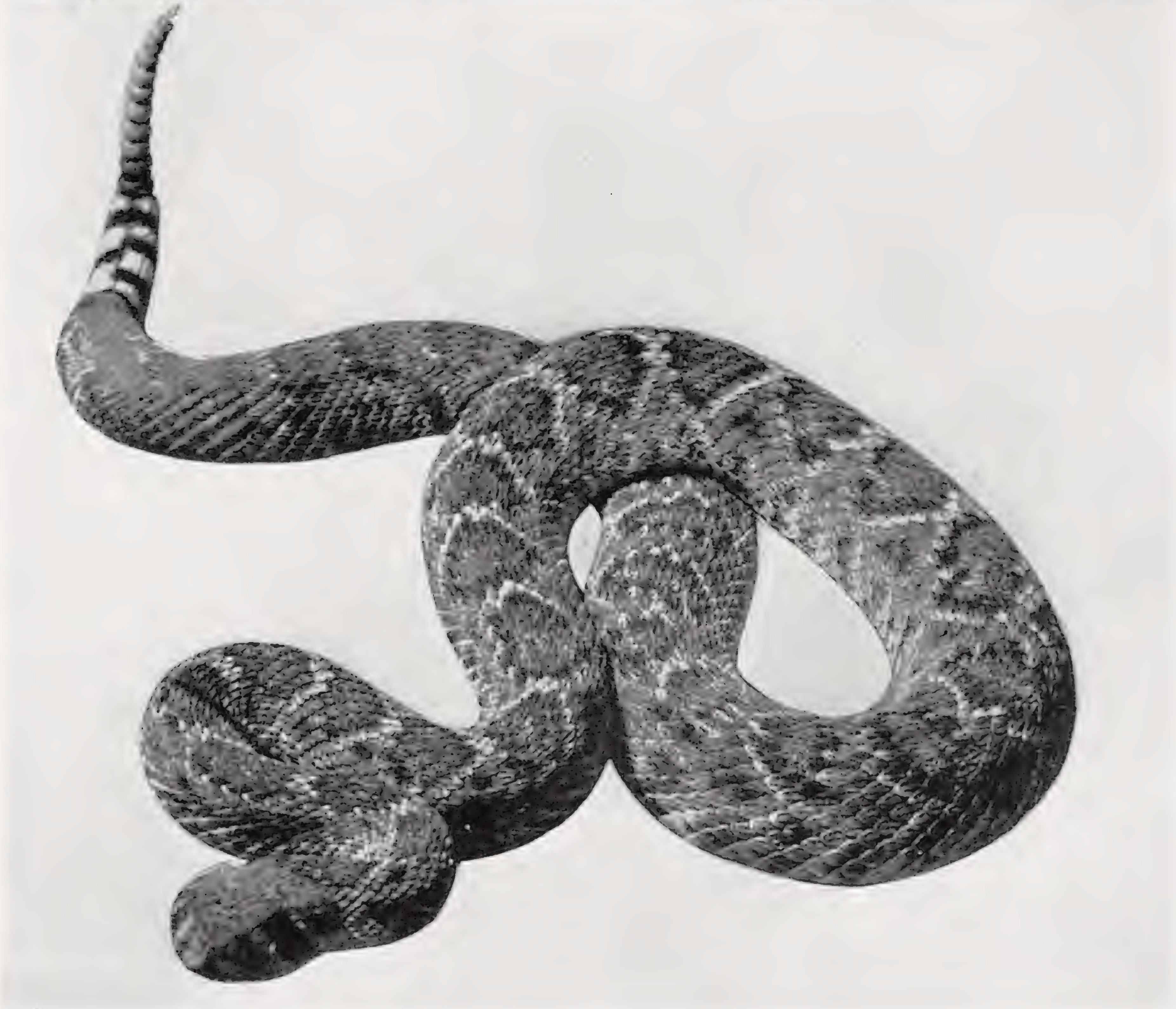




Upper—Fig. 43. Tropical Rattlesnake, *Crotalus terrificus terrificus* (the typical form). This specimen is from southern Brazil. The neck bands are shorter than with Central American specimens.

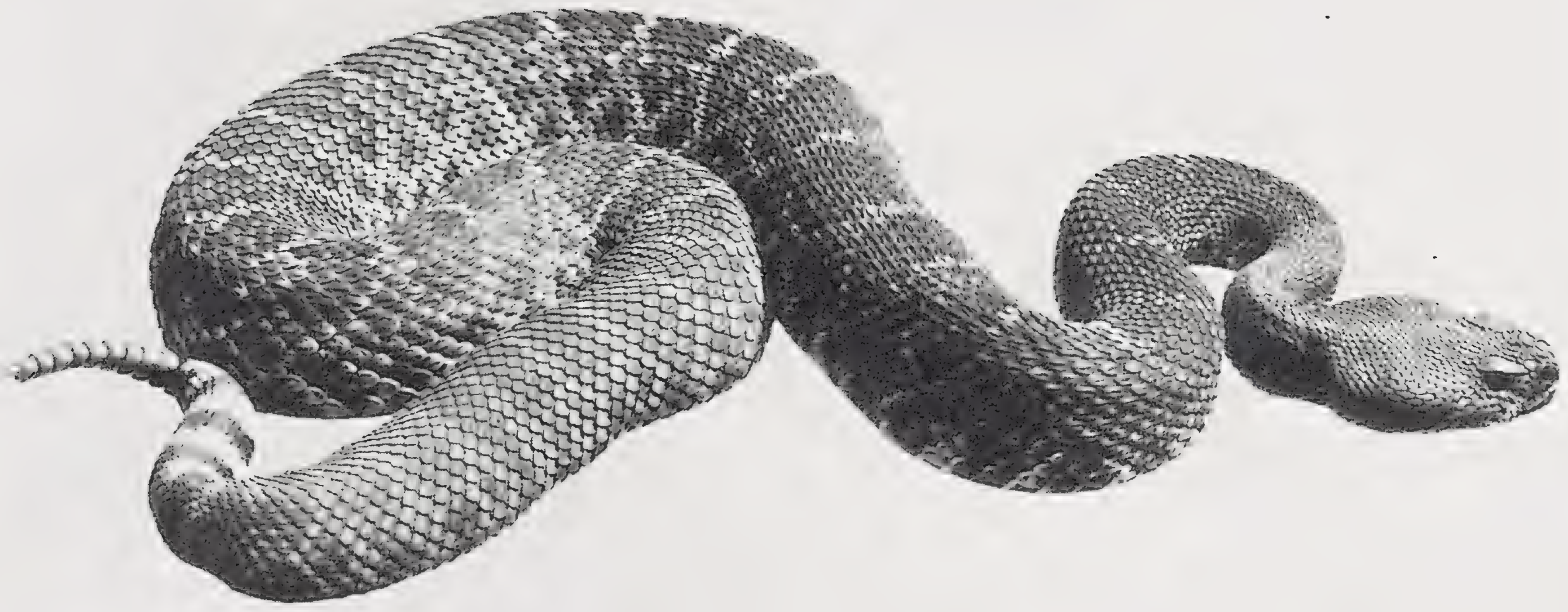
Lower—Fig. 44. Black-tailed Rattlesnake, *Crotalus molossus*. The boundary region of the United States, from Texas to Arizona inclusive; also Mexico. Appears to be closely related to the tropical species found southward. Photograph courtesy of Dr. A. H. Wright.

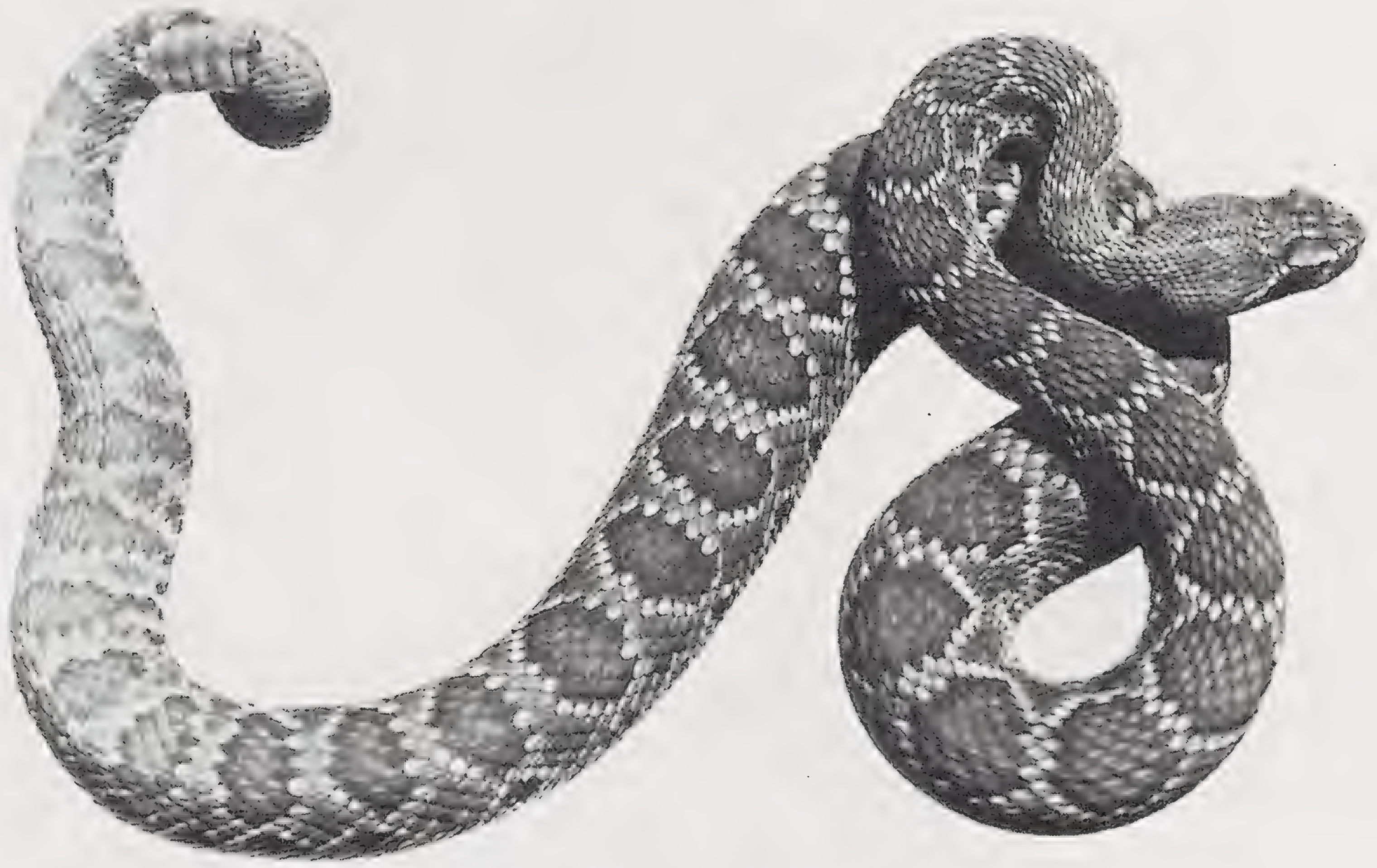




Upper—Fig. 45. Eastern Diamond-back Rattlesnake, *Crotalus adamanteus*. Largest of North American rattlesnakes. It attains a length of eight feet and weight of fifteen pounds. Occurs in coastal areas of the southeastern United States.

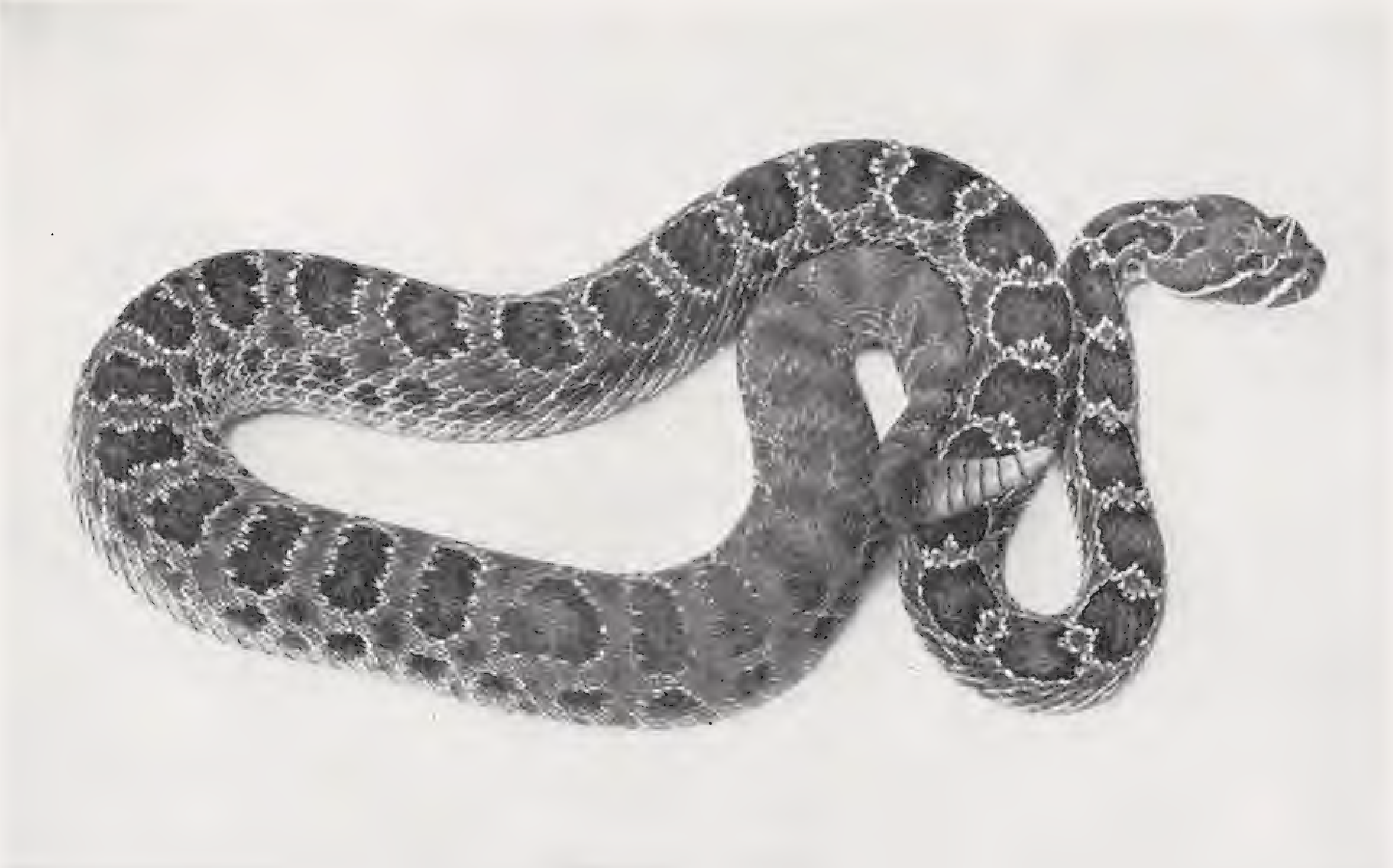
Lower—Fig. 46. Western Diamond-back Rattlesnake, *Crotalus atrox*. Second in size to the eastern diamond-back. The range is from Texas to California. Owing to its abundance and inclination to quickly strike, it holds first rank in the number of fatalities from rattlesnake bites.

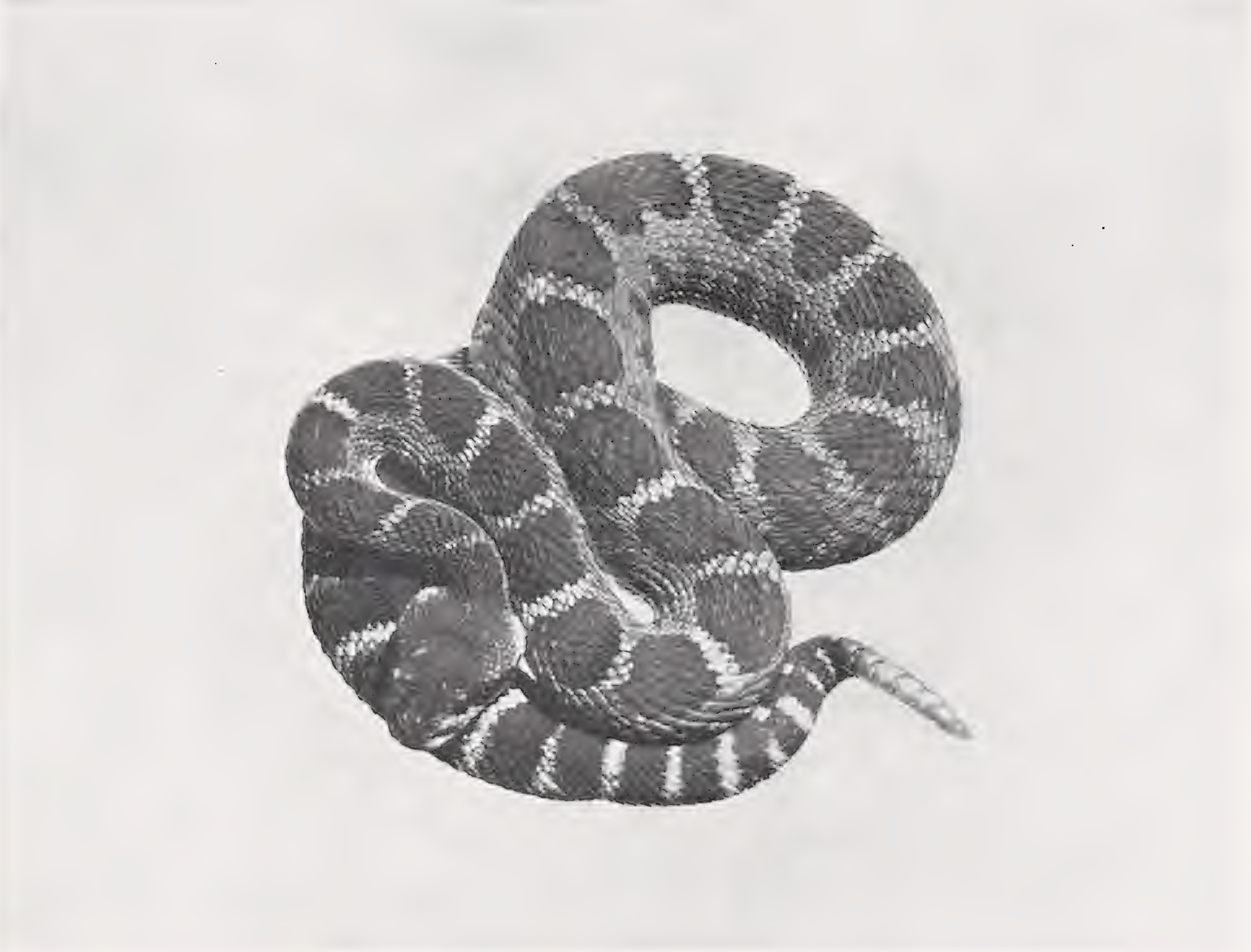




Upper—Fig. 47. Red Diamond Rattlesnake, *Crotalus ruber*. Southern California and lower California. A rather common and large rattler of ordinarily passive disposition. Accidents from it are seldom recorded. It is difficult to induce some specimens to sound the rattle.

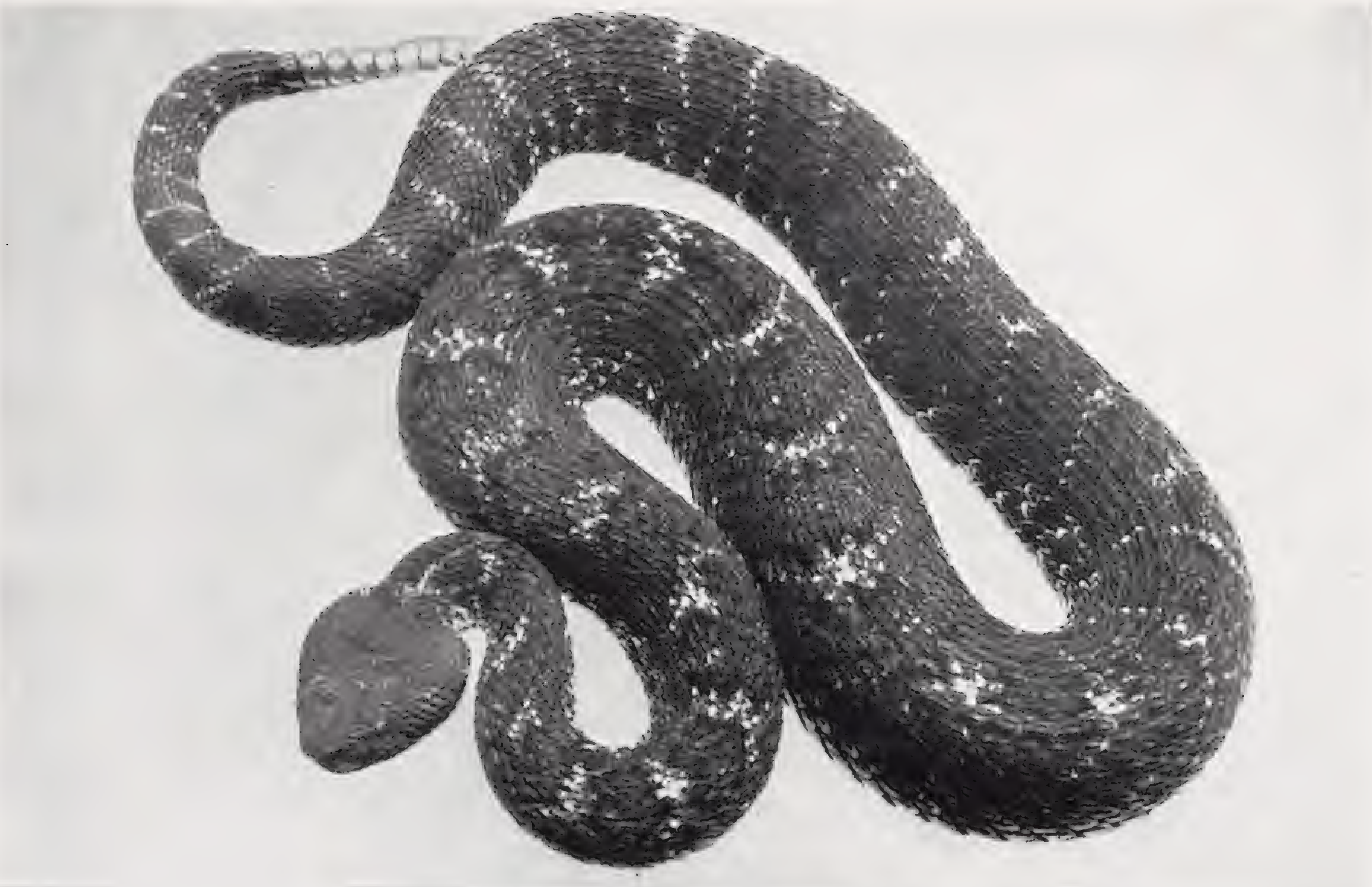
Lower—Fig. 48. Mohave Diamond Rattlesnake, *Crotalus scutulatus*. Recognized by the enlarged scales on the top of the head. Inhabits the arid Southwest, into northern Mexico. Photographs courtesy of Laurence M. Klauber.

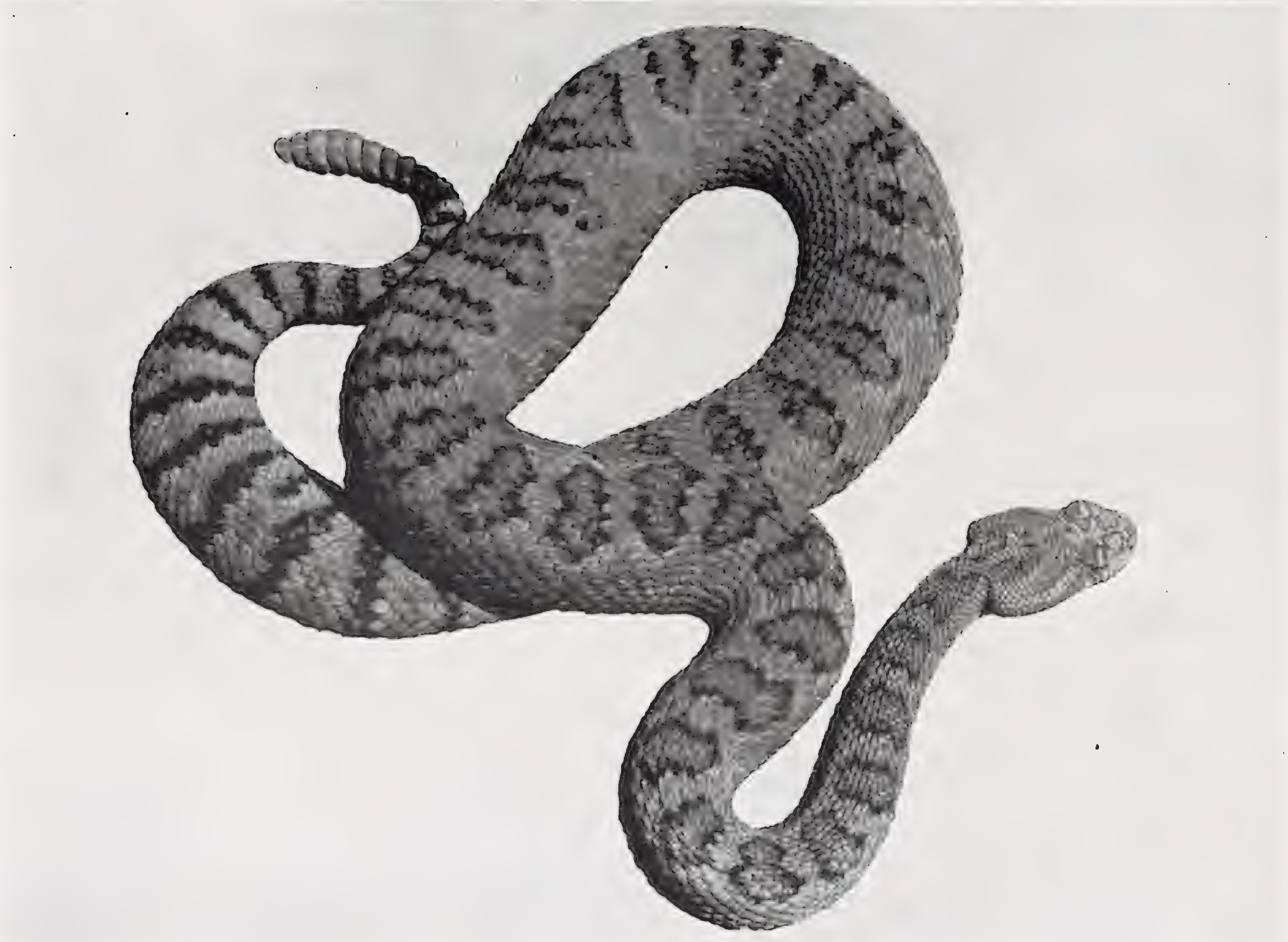




Upper—Fig. 49. The Prairie Rattlesnake, *Crotalus confluentus confluentus.* Its races or subspecies have the widest range of any of its genus. The common rattler of the plains.

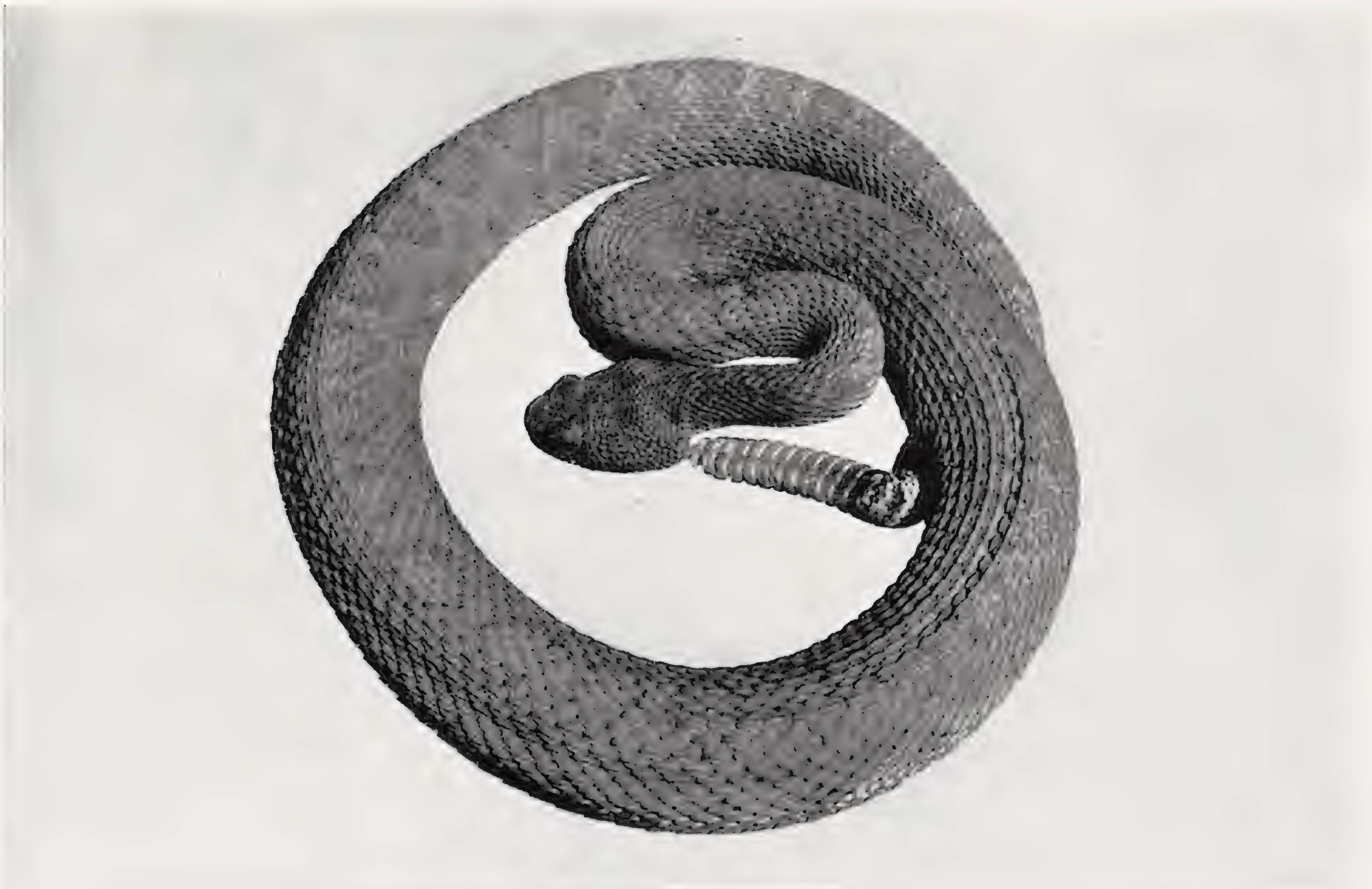
Lower—Fig. 50. Pacific Rattlesnake, *Crotalus confluentus oreganus.* The common and only rattlesnake of the Pacific region north of southern California, in which latter area other species occur. Abundant over varied country embracing mountains, sea coast levels, inland plains and sterile areas. Coloration varies from brown, gray, greenish to black. Photograph courtesy of Laurence M. Klauber.

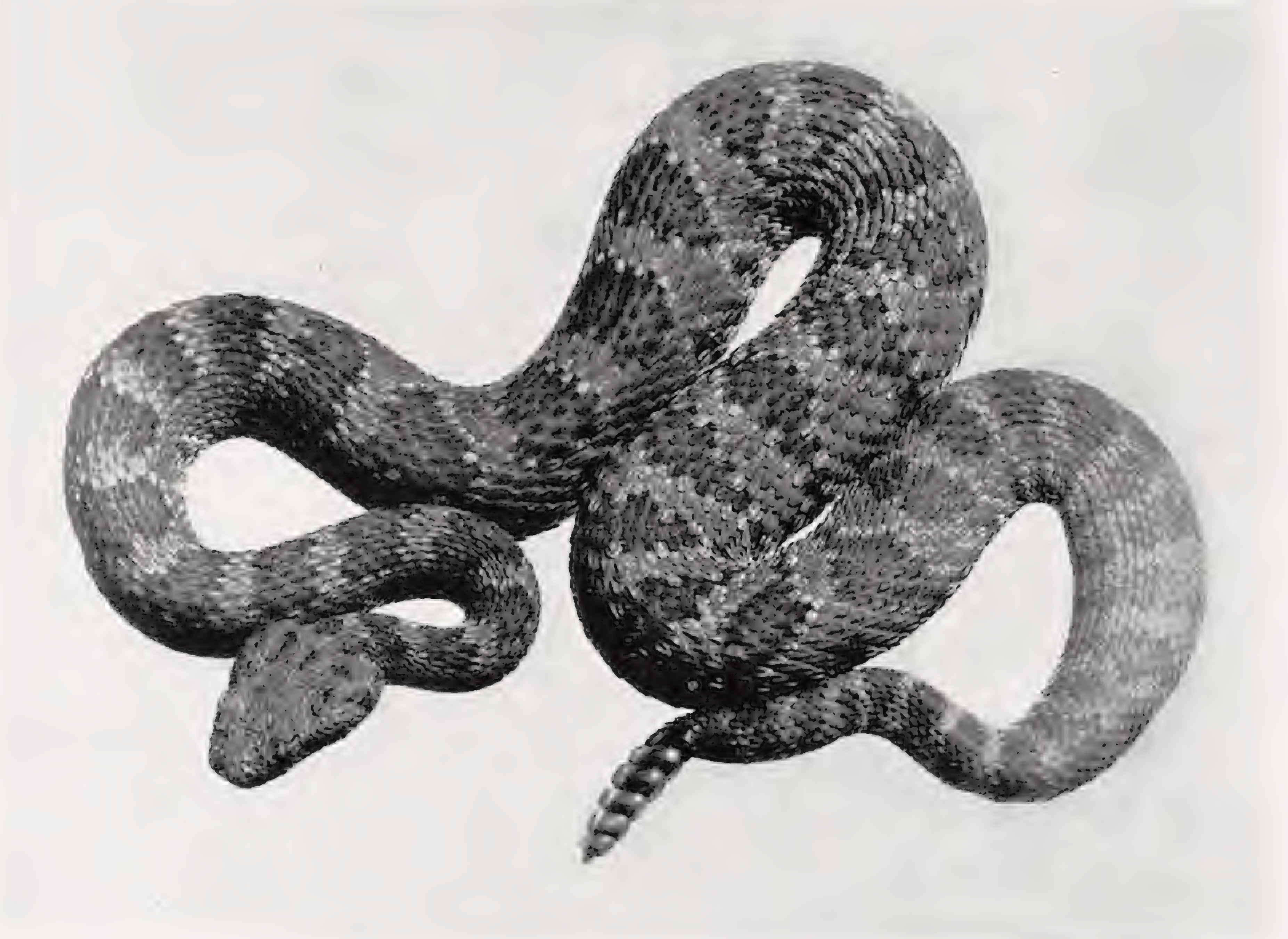




Upper—Fig. 51. Pacific Rattlesnake, *Crotalus confluentus oreganus*, black phase. With black examples the blotches are fused out, the only pattern being their paler margins, forming a chain of whitish rhombs.

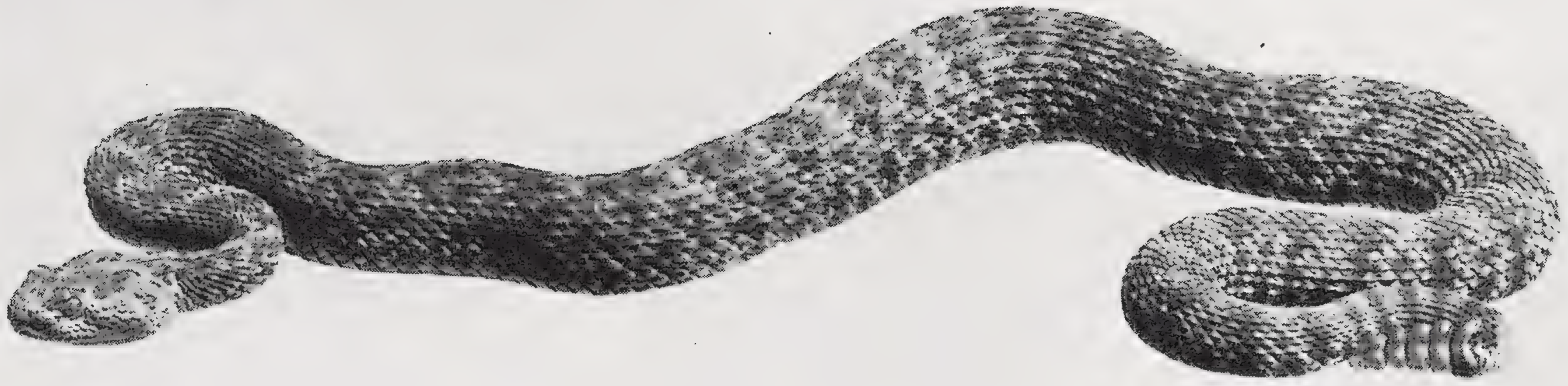
Lower—Fig. 52. Great Basin Rattlesnake, *Crotalus confluentus lutosus*. The Plateau Region from the Rockies to the Sierras. Photographs courtesy of Laurence M. Klauber

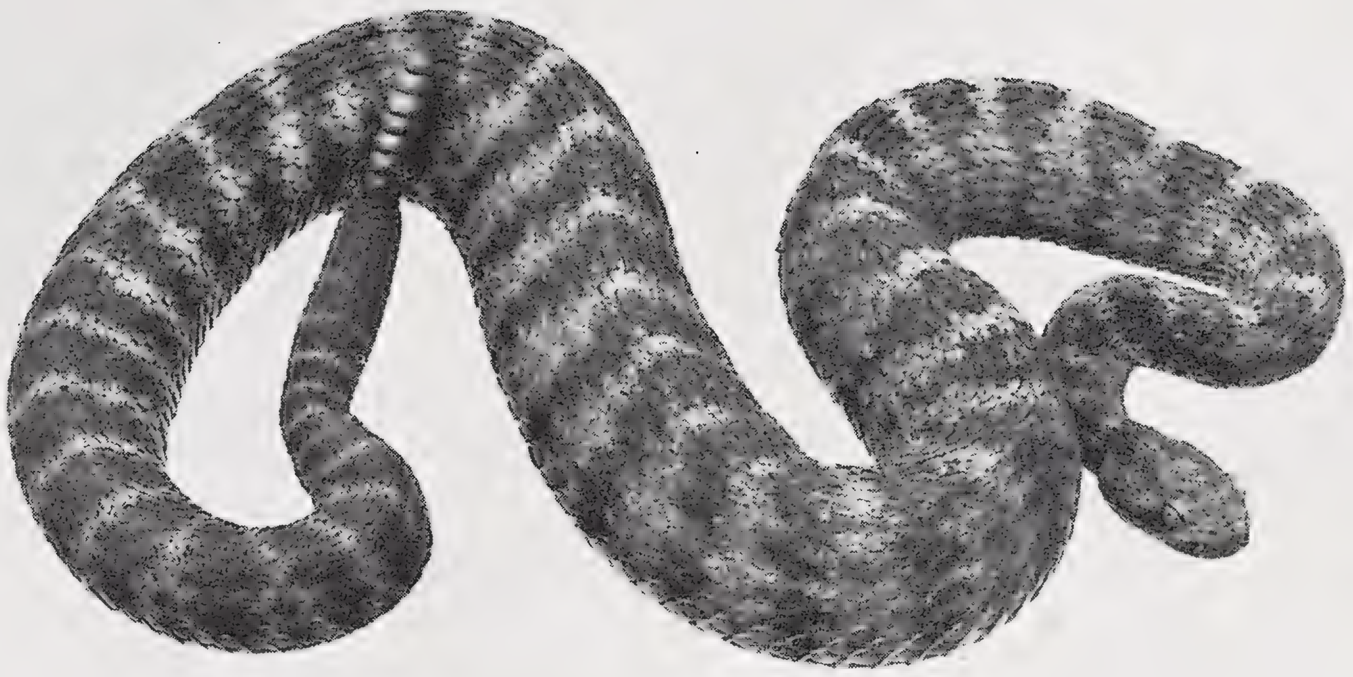




Upper—Fig. 53. Grand Canyon Rattlesnake. *Crotalus confluentus abyssus.* Observed only in the Grand Canyon of the Colorado, in Arizona. Distinguished by its vermilion or salmon coloration, and almost complete absence of pattern when adult.

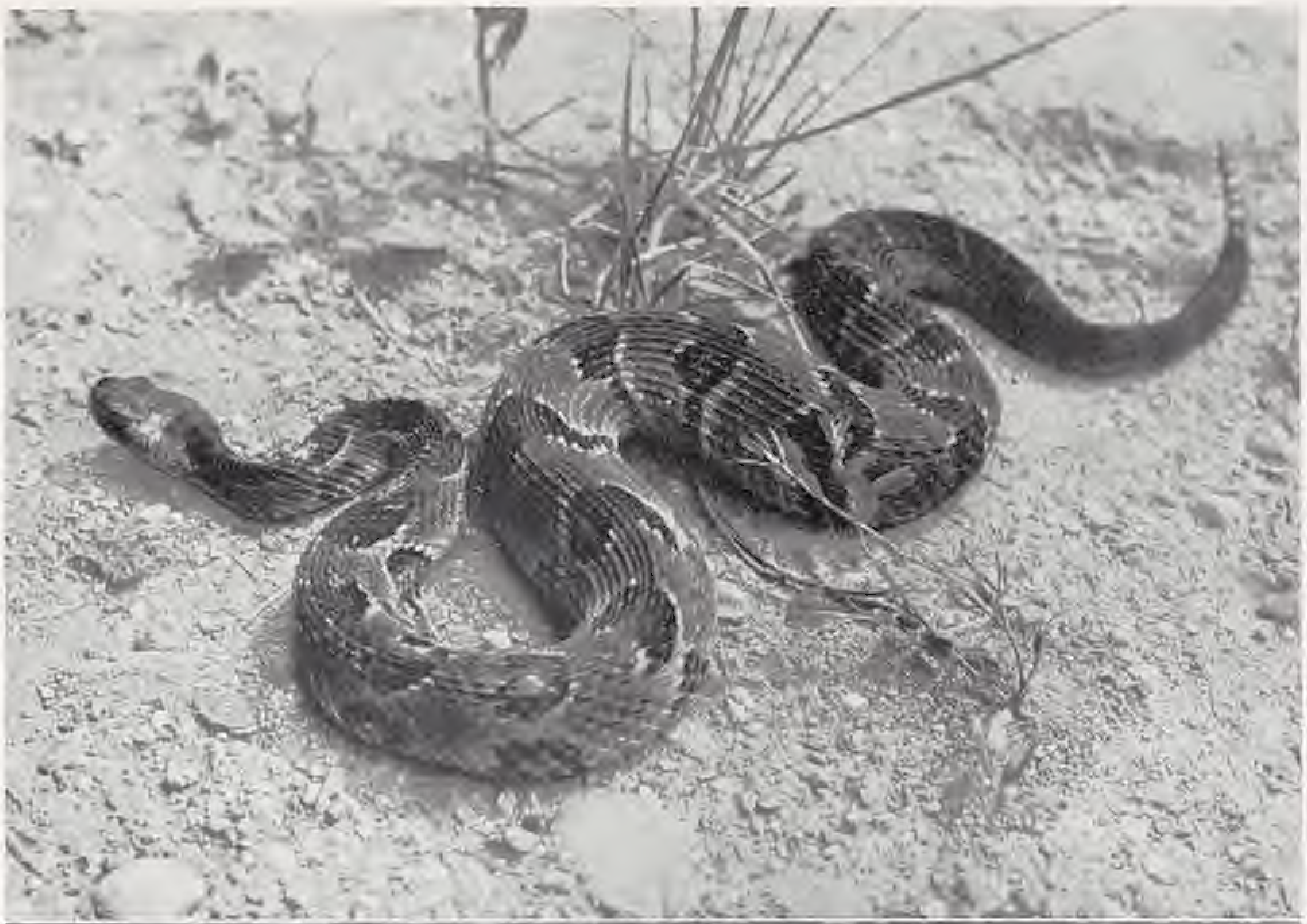
Lower—Fig. 54. Panamint Rattlesnake, *Crotalus confluentus stephensi.* A pallid, desert form, recorded from Nevada and eastern California. Photographs courtesy of Laurence M. Klauber.

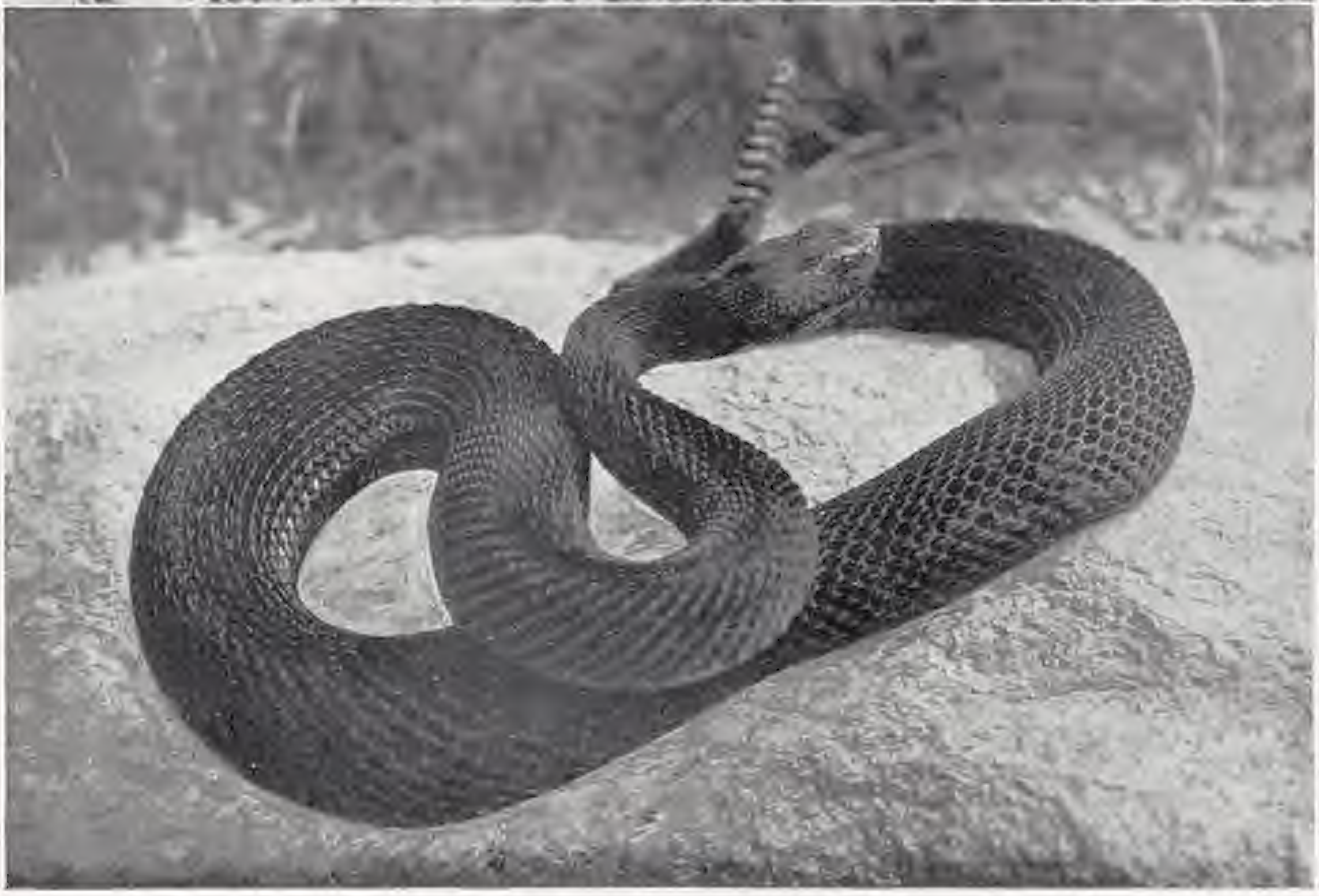




Upper—Fig. 55. White Rattlesnake; Bleached Rattlesnake, *Crotalus confluentus mitchellii.* Deserts of Arizona, southern and Lower California. The arid Southwest is the headquarters of the rattlesnakes. Over a dozen species occur in that region. Elsewhere over the far-flung area inhabited by such serpents, from Canada to Argentina, there is no such grouping of species, two or three being the maximum number overlapping in distribution.

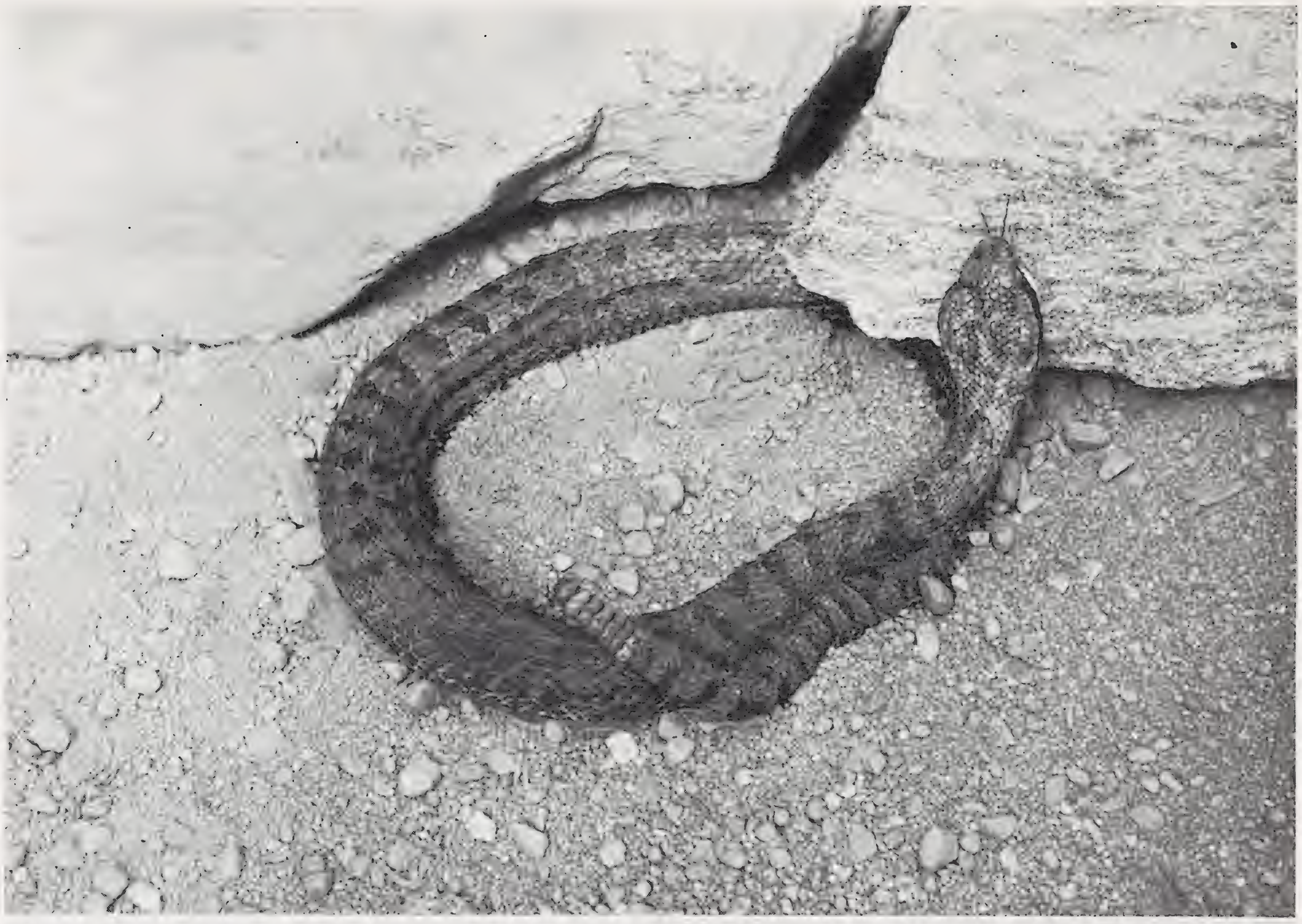
Lower—Fig. 56. Tiger Rattlesnake, *Crotalus tigris.* Another resident of the Southwest. Photographs courtesy of Laurence M. Klauber.

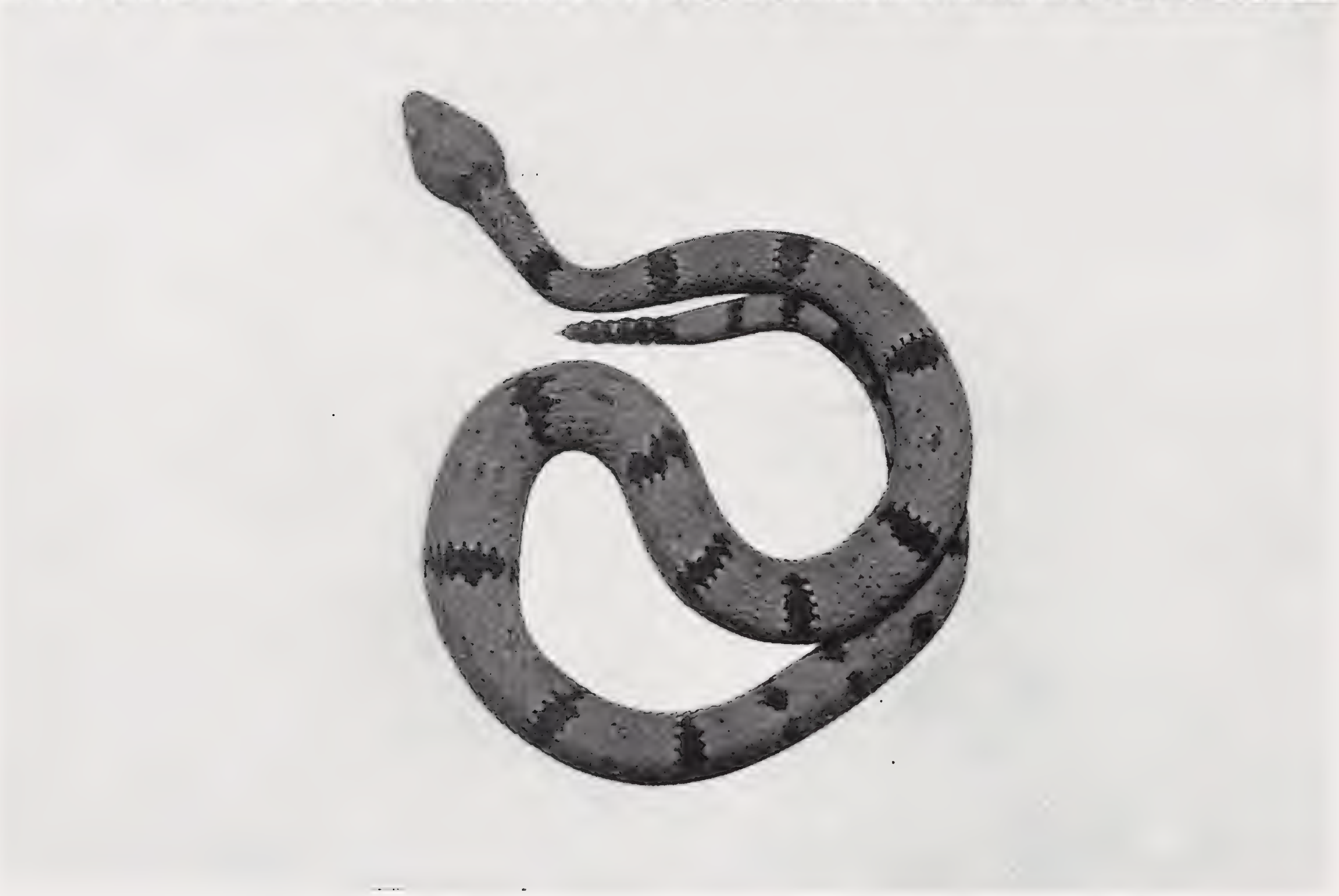




Upper—Fig. 57. Banded Rattlesnake; Timber Rattlesnake, *Crotalus horridus.* The common rattler of the eastern United States. Particularly abundant in northeastern areas. Frequents ledges on hills and mountains and congregates during the autumn near specific crevices, which are the hibernating shelters or "dens." It is not a savage species and records of bites are comparatively rare.

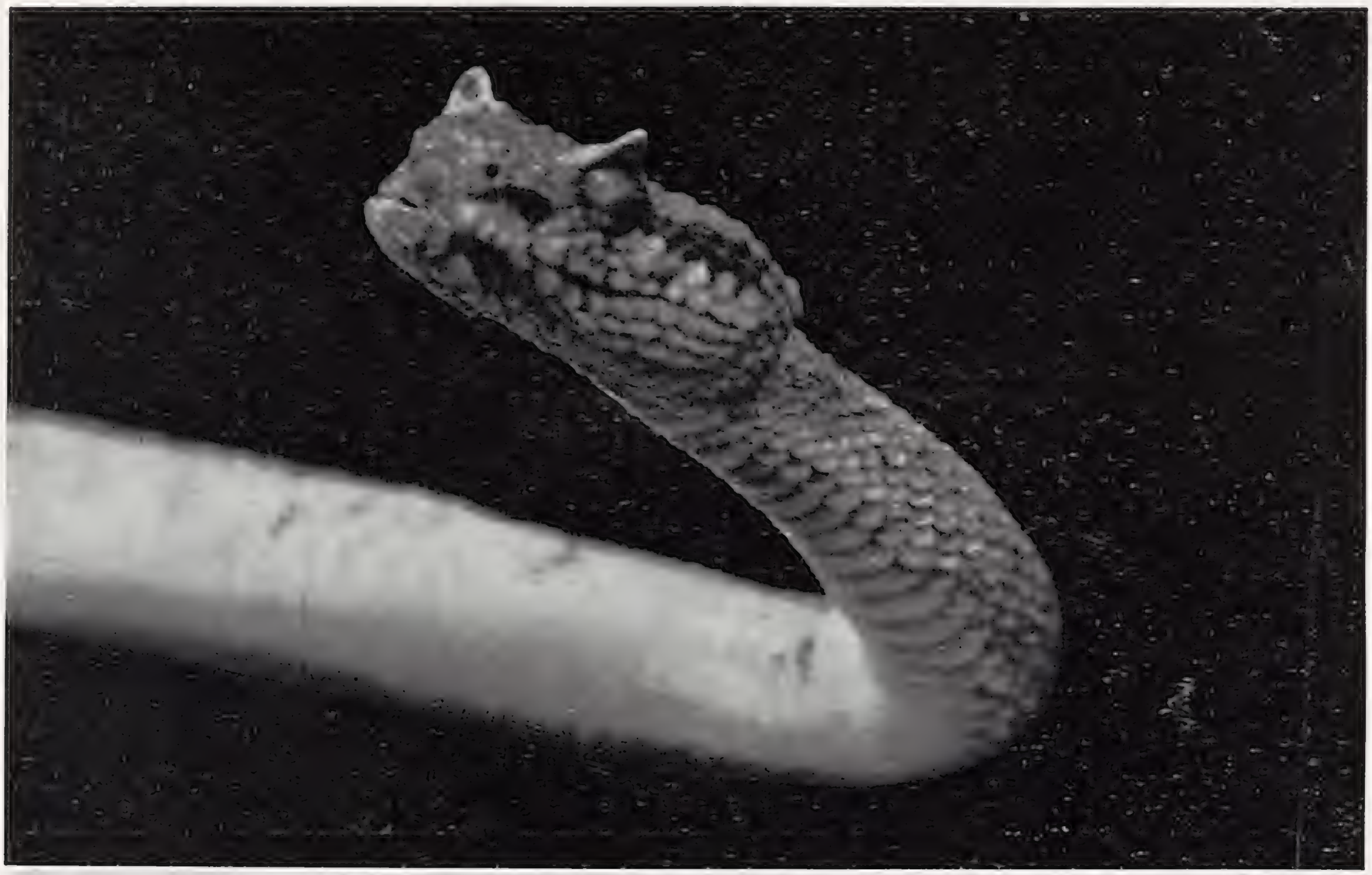
Lower—Fig. 58. Banded Rattlesnake, *Crotalus horridus* (black phase). There is much variation in hue and intensity of pattern.

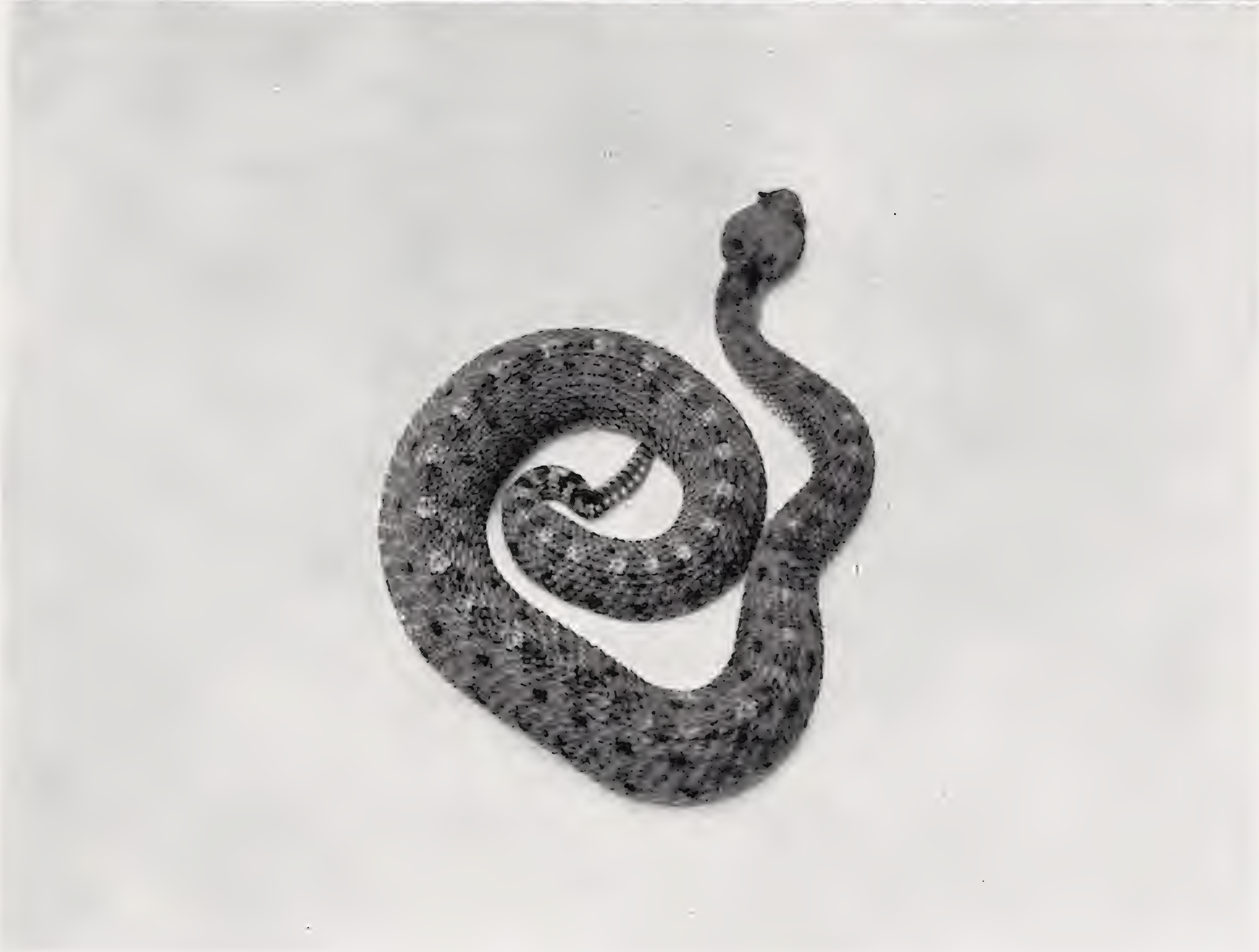




Upper—Fig. 59. Spotted Rattlesnake, *Crotalus triseriatus*. A small, grayish species of the Southwest—including northern Mexico.

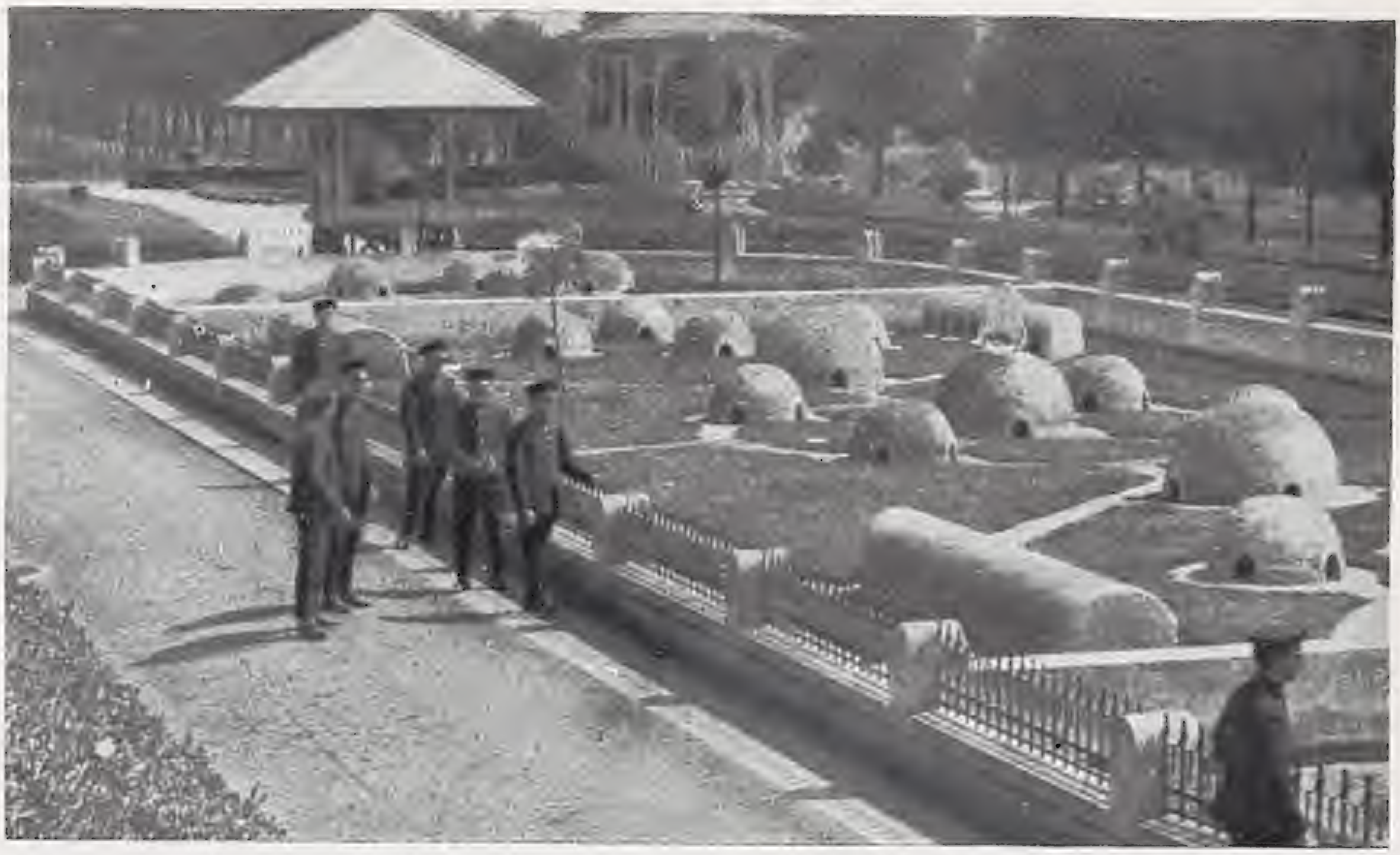
Lower—Fig. 60. Green Rattlesnake, *Crotalus lepidus*. Readily distinguished by its greenish-gray hue, marked by widely separated rings of black. Of small size and found only in the Southwest. Photograph courtesy of Dr. A. H. Wright,





Upper—Fig. 61. Head of the Horned Rattlesnake, *Crotalus cerastes.*

Lower—Fig. 62. Horned Rattlesnake; "Sidewinder," *Crotalus cerastes.* Deserts of the Southwest. Characteristic in having a horn-like scale over each eye. Living on dry and yielding sand, it progresses by throwing lateral loops of the body forward, which cause it to move off at an oblique angle to the direction in which the head is pointing—hence the name "Sidewinder."



Snake pit at Sao Paulo, Brazil. This extensive and pretentious pit is surrounded by a water moat. It is part of the Instituto Soro Therapico, where large quantities of serum are prepared for snake bite accidents in Brazil.

The snake pit at Tela, Honduras. The object of the numerous shelters is to enable the extremely nervous reptiles to hide or otherwise they would soon die. The scientific worker is particular about wearing leather leggings on entering the pit. This pit is contained in the large structure shown on page 98.

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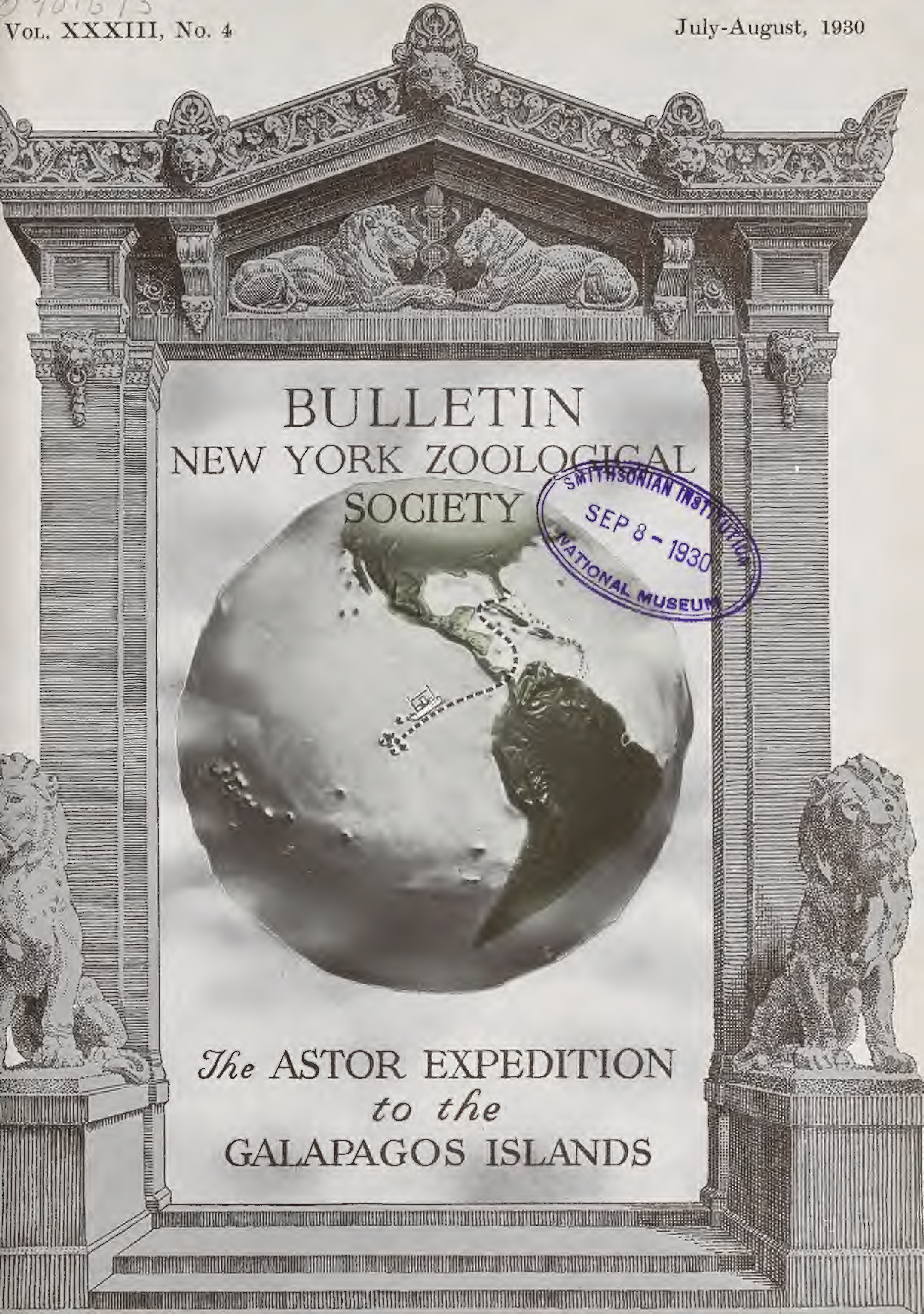

BULLETIN
NEW YORK ZOOLOGICAL SOCIETY

SMITHSONIAN INSTITUTION
SEP 8 - 1930
NATIONAL MUSEUM

The ASTOR EXPEDITION
to the
GALAPAGOS ISLANDS

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GIANT TORTOISE OF INDEFATIGABLE ISLAND.......*Painting by Wilfred S. Bronson* *Frontispiece*
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BULLETIN

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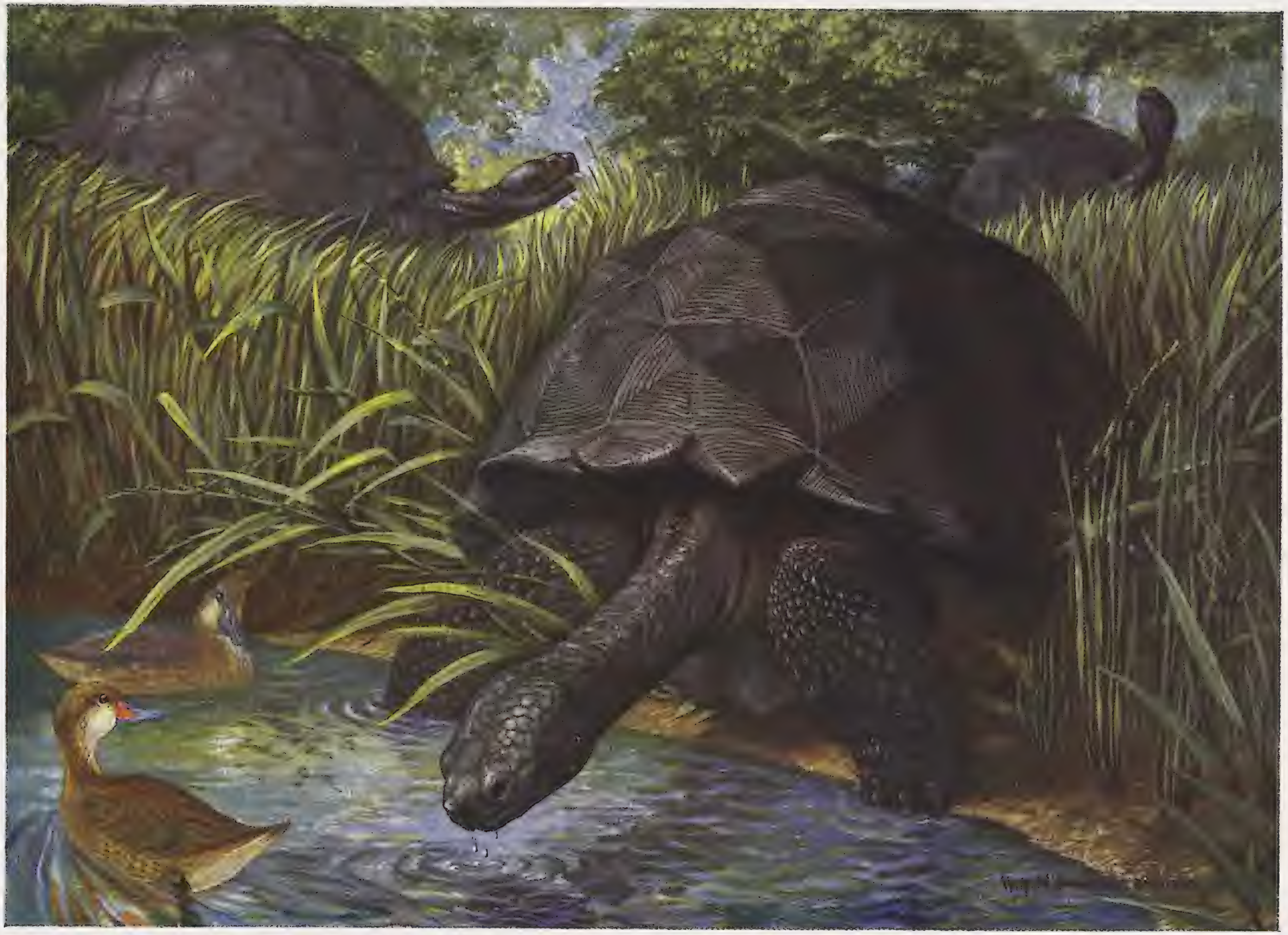

The Giant Tortoise of Indefatigable Island. Each island of the Galapagos group had its own distinct species of land tortoise. Most of these are now extinct. The species shown here is *Testudo porteri.* During the early part of the nineteenth century large numbers of this tortoise were taken from Indefatigable Island where it is now rare. The Astor Expedition secured eight live specimens for propagation. Below are shown native ducks (*Poecilonetta galapagensis*).
Painted from life by Wilfred S. Bronson.

BULLETIN
NEW YORK ZOOLOGICAL SOCIETY

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The Astor Expedition to the Galapagos Islands

Charles Haskins Townsend

Illustrated from photographs made by various members of the expedition.

Introduction

DURING the past sixty years the Galapagos Islands have been visited by a good many naturalists. While their peculiar animals and plants are now fairly well known, the field for investigation remains a broad and inviting one.

When Mr. Vincent Astor decided on going there in the large and speedy yacht *Nourmahal*, he felt that the voyage should contribute something to the knowledge of a fauna and flora known to be of unique scientific interest. The writer was invited to recruit a party of naturalists to accompany the ship with this purpose in view. Certain of Mr. Astor's friends, interested in seeing the islands and in angling for the large fishes to be found among them, had already accepted his invitation to go there and wished to participate in the proposed explorations.[1]

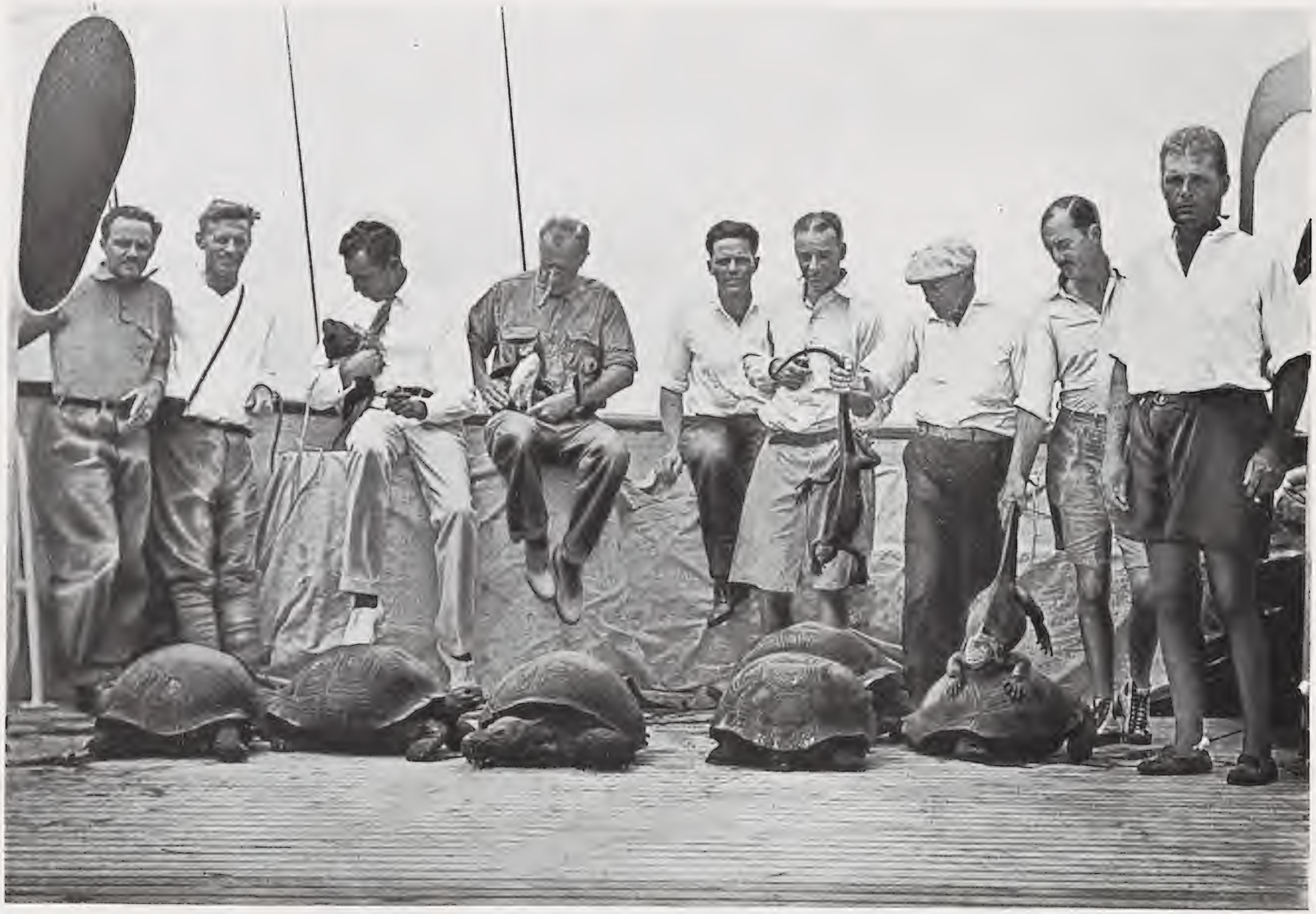
It was decided that the efforts of the expedition should be directed chiefly to the exploration of the one island about which the least was known. This was Indefatigable, the second in size of the Galapagos group of a dozen large islands. It was named a hundred years ago for a British warship that made some survey of its coast. Its high interior remains largely unknown, geographically, zoologically, and botanically, except for what we were able to learn during the two weeks devoted to it. Little attention was paid to marine life, which remains unaffected by the human agencies that have been so profoundly disturbing to the land fauna. The extinction of the once abundant Galapagos fur seal (*Arctocephalus philippi*) may be cited as an exception among marine forms.

Our explorers and naturalists worked their way into Indefatigable Island somewhat farther than the few expeditions that had preceded them on this island.[2] They reached an elevation of 2100 feet as indicated by aneroid barometers. It is a rough volcanic island, covered with tangled vegetation. The barrier of jungle present from the coast inwards, was found to be no less difficult after four days of arduous hacking with machetes. At the point

---

[1] The party on board the *Nourmahal* during the cruise to the Galapagos Islands was, Commodore Astor, Kermit Roosevelt, Suydam Cutting, Robert Huntington, Dr. Eugene Pool of the New York Hospital, Clarence L. Hay of the American Museum of Natural History, James P. Chapin, ornithologist, American Museum of Natural History, H. K. Svenson, botanist, Brooklyn Botanic Garden, Wilfred S. Bronson, artist, Charles H. Townsend, New York Aquarium, who acted as director of the expedition and Elwin R. Sanborn, photographer, New York Zoological Society.

[2] The details of this difficult piece of work are described elsewhere by Mr. Roosevelt.



On Board the Nourmahal. *Left to right*—Bronson, artist; Chapin, ornithologist; Mr. Astor; Dr. Pool; Svenson, botanist; Cutting; Townsend; Hay; Huntington. *Below*—Tortoises of Indefatigable Island (*Testudo portei*). (Roosevelt and Sanborn are at the camera.)

reached, the highest part of the island was known to be near, but lofty outlooks could not be found and nowhere was it possible to see far ahead. The inland party was accompanied to this point by collectors and important zoological and botanical material was secured.

The lack of water and food, exhausting labor, heat and discomfort from mosquitos made it necessary to fall back on a half way base, where further collecting was done before a return to the coast. We now believe that there is little to support the old theory of a great central crater so long sketched *on the chart*. While there may be some rather more level country in the interior, it is probable that jungle covers all parts of the interior just as it does the slopes. Photographs of the sky-line from both north and south of the island show rounded eminences, not sharp rocky pinnacles except on the north side. They appear to be brush covered almost to their tops, like those nearer the coast, easily examined with field glasses.

Indefatigable Island is twenty-five miles in diameter and it must have been a ten-mile journey to the height that was reached. Any attempt to penetrate this island from any point around the coast is most discouraging. No progress is possible anywhere without cutting a way. Although its highest point is supposed to be little more than 2300 feet, it is the most difficult of all the Galapagos Islands to explore. No one can go anywhere without carrying the day's supply of water. This is true, however, of most of the other islands of the group.

Although the coastal regions of the Galapagos Islands are all desert-like and waterless, the higher parts are often hidden by rain clouds. While there are some permanent pools in the higher regions, the volcanic nature of the islands in general does not permit of the retention of water on the surface.

The islands of the Galapagos group occupy a sea area of more than 130 miles in diameter and are mostly of considerable size. The largest is 75 miles long and has volcanic heights up to 5,000 feet. Most of them have never been inhabited except temporarily and could not be without complete provision being made for subsistence. There are two small settlements of natives of Ecuador on islands a hundred miles apart. These are Chatham and Albemarle. Except for a couple of transiently occupied camps elsewhere, the rest of the archipelago lies unused and is seldom visited. There is no regular transportation between the mainland and the islands. Although lying under the Equator, the climate of the Galapagos Islands is not one of equatorial heat.[3] It is tempered by an Antarctic current that flows among them. The tourist would find little of interest in these islands, so difficult to penetrate, aside from views of vast lava fields, forbidding cliffs, wild anchorages in half-submerged craters and other volcanic phenomena. Their chief interest is for the lover of nature, inspired by Darwin's account written a hundred years ago. When a young man Darwin served as naturalist on the "Beagle" and made the voyage of that ship celebrated because of his writings. The early navigators—some of them more than a century ahead of him—had told the world the story of the giant tortoises. It was not until the great naturalist arrived that other wonders of animal life were made known.

The attractive features of the Galapagos Islands are those connected with the peculiar animal and plant life existing there. When discovered in the sixteenth century, they were named the *tortoise* islands because of the astonishing numbers of "galapagos" inhabiting them. Each island had its own distinct species of giant land tortoise.

One of the objects of the expedition was to ascertain if the tortoise of Indefatigable Island was still in existence and to procure specimens for breeding purposes. The mountain party explored each zone of elevation from the coast upward. The collections included giant tortoises, lizards, several kinds of finches, some flycatchers, thrushes, and doves. Insects were also obtained. The botanist collected many kinds of plants and has doubtless species that are new to this island. The field for botanical and entomological research in the Galapagos archipelago remains but half explored.

One of the ever charming features of these islands is the tameness of the land birds. It is only necessary to sit quietly anywhere to have

---

[3] Temperatures of air and water were recorded on board the *Nourmahal* every four hours, day and night during our stay among the islands. (Mar. 31 to Apr. 15). Average temp. of air 80°—water 78° Fahr.

Heron. Indefatigable Island.

several of them come almost within arm's length. The doves came close to one's feet; the thrushes, finches, and flycatchers perch near enough to be touched with a switch if they did not move. The hawks are so inquisitive that we caught them with a string noose on the end of a stick. It is not uncommon to see half a dozen of them on a single low tree. The big marine and land iguanas offer no difficulty in capture. One has only to slip up quietly and seize them by the tail. The sea lions of the Galapagos (*Otaria jubata*) are amazingly fearless for large animals. The baby sea lions are full of curiosity and do not bite when picked up.

While the shore parties were at work on Indefatigable Island, the *Nourmahal* made trips to other islands in search of living animals for the Aquarium and the Zoological Park. It was not difficult to capture penguins and flightless cormorants. These birds, being unable to fly, were caught with dip nets on the rocks before they could jump into the water. The penguins soon became pets, while the cormorants remained vicious as when caught, actually thrusting their heads from the cages to strike at anyone within reach of their hooked beaks. They were so savage with each other that it became necessary to keep them in separate cages.

The upper deck of the *Nourmahal* with its cages of birds, iguanas, and tortoises, had the appearance of a small menagerie during the return voyage. There was also a tank containing a large Pacific sea turtle (*Chelonia virgata*) which members of the party caught in the water with their hands. The Pacific green turtle has not previously been seen at the Aquarium.

An important feature of the expedition was the carrying of 265 Galapagos fishes to New York *alive*. Sea water was kept flowing through the tanks day and night, except during the seven hours' passage through the fresh waters of the Panama Canal, where the tanks were supplied with compressed air. The losses were surprisingly few, as the fishes were in the shipping tanks fully three weeks. Hauling live sea fishes 3,000 miles had not previously been done. We are disposed to regard this as somewhat of an achievement. It would hardly have been

Pintail Ducks (*Poecilonetta galapagensis*), Indefatigable Island. Photograph by James P. Chapin.

attempted had it not been for Mr. Astor's interest in making the trial.

While under the patronage of the New York Zoological Society, which was represented by three of its officers, the American Museum of Natural History and the Brooklyn Botanic Garden also contributed workers in special lines.

The Aquarium and the Zoological Park received all the living animals, and the Museum and the Botanic Garden the preserved material. The results of the expedition do not consist of natural history collections alone. There are important photographs and paintings for the illustration of natural history documents which will be prepared after the collections have been studied. The note-book records that have been made, indicate that these contributions will extend the present knowledge of the Galapagos Islands. The above named institutions of New York have profited greatly through the munificence of the promoter of this expedition, Mr. Vincent Astor, who participated actively and with lively interest in all its proceedings.

Notes on the Collections

The Giant Tortoise of Indefatigable Island[4]:—We were fortunate in finding at this island two survivors of a Norwegian colony that had found the conditions of life unfavorable and returned to their native land or to points in South America. These men reported that giant tortoises were still in existence on the island and offered to conduct us to the distant tortoise country. Most of our party, including Mr. Astor, made the trip. It was over a dim and rough trail which could not have been followed without the guidance of the two Norwegians and their one native companion. It proved to be a hard, grilling march of five hours' duration. We had little idea of the number of miles, and we needed all the water our canteens contained. On a second trip to the tortoise country, we camped over night for the sake of a tortoise hunt, following the three natives as they pushed through the brush. After an hour's work, on the evening of our arrival, we found a tortoise weighing perhaps 250 pounds. It was too large for transportation and was left at liberty. The natives

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[4] *Testudo porteri.*

Pintail Ducks (*Poecilonetta galapagensis*). Indefatigable Island. Photograph by James P. Chapin.

Thrush (*Nesomimus melanotis dierythrus*). Indefatigable Island. Photograph by James P. Chapin.

brought in eight of smaller size, seven of which ranged from 40 to 80 pounds in weight. These were brought to the Zoological Park. The natives had a horse on which the tortoises were carried to the coast. Two heavy tortoises at a trip, made hard work for the little horse, considering the roughness of the trail. His unshod hoofs suffered in consequence.

This species of tortoise (*Testudo porteri*) is found only on Indefatigable Island. Its existence being in doubt, the living specimens secured are of decided value. While in the tortoise country we measured the bleached shells of large tortoises killed years before. Some of them were nearly five feet in length of top shell as measured over the curve. They must have weighed considerably over 500 pounds.

Giant tortoises have long been extinct on most of the Galapagos Islands. Ships have been carrying them away for food for 300 years, by hundreds of thousands. The stock was finally reduced to small numbers by whaling vessels before the middle of the nineteenth century. There is little hope for their continued survival in the mountains of the two large islands where they are still to be found. Temporary settlers from Ecuador have left behind them dogs, pigs, cats and rats, to run wild and multiply. All of these prey upon newly hatched tortoises, so there can be little increase. It is still the habit of the natives of the two remaining settlements to kill and eat giant tortoises wherever they can be found. The few carried away alive by naturalists, count for little in view of the killing that still goes on. Being now far inland they are no longer sought by passing merchant ships.

It is fortunate that numerous giant tortoises were brought from the mountains of Albemarle Island two years ago by the writer, under the direction of the New York Zoological Society.[5] These tortoises have been colonized in Florida and elsewhere in warm climates. Most of them have already doubled in size. There is reason to believe that they will soon reach the breeding age. With Mr. Astor's approval, the tortoises from Indefatigable Island will also be colonized

Yellow-crowned Night Heron (*Nyctanassa violacea*), Indefatigable Island. Photographed by James P. Chapin.

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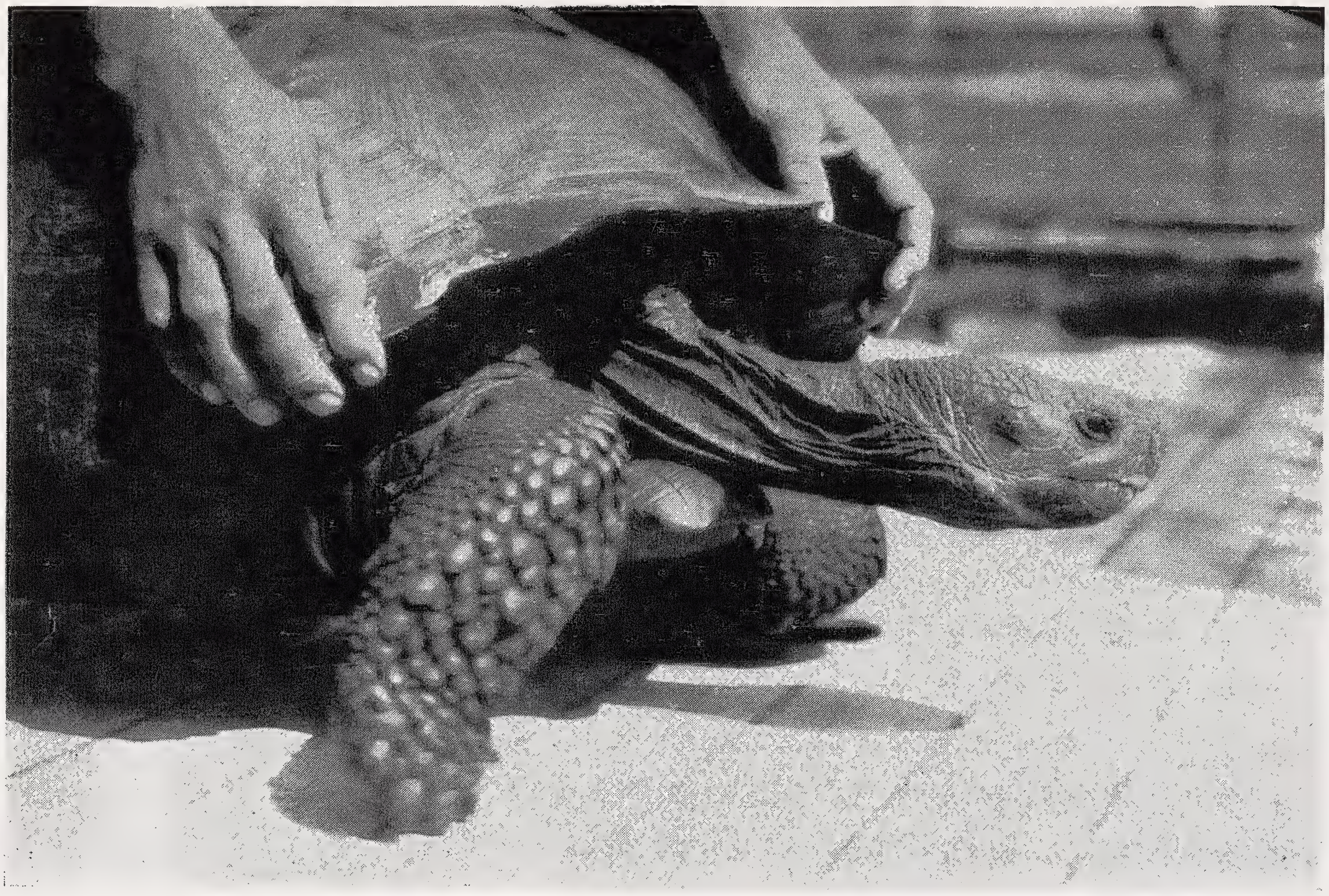
[5] For this purpose the U. S. Bureau of Fisheries lent the *U. S. S. Albatross II.*



Tortoise of Indefatigable Island (*Testudo porteri*). Showing heavy scale armor of legs.
Photograph by H. K. Svenson.

in the south for propagation of this particular species. It is now evident that they grow rapidly. The breeding age is still unknown.

There are before me records of certain whaleships that took 753 tortoises from Indefatigable Island between 1824 and 1848. These dates include a period when there were over seven hundred ships in the American whaling fleet. As most of the fleet engaged in sperm whaling in the Pacific and frequently called at the Galapagos for supplies of tortoises, the numbers carried away must have been very great. The writer has records of 105 ships that captured fifteen thousand tortoises on different islands of the group during the early part of the nineteenth century.

Captain Porter of the *U.S.S. Essex,* at the Galapagos in 1812, records finding tortoises in abundance on Indefatigable Island, "one of which measured five feet and a half long, four feet and a half wide, and three feet thick; and others were found by some of the seamen of larger size." Porter confesses to loading one of his ships at James Island with tortoises that "would weigh about fourteen tons. At Charles Island between four and five hundred were taken on board." Feeding the crews of warships and whaleships on "Galapagos Mutton" as it was called, required large numbers of tortoises.

The California Academy of Sciences Expedition of 1905 secured twenty-three tortoises on Indefatigable Island, the largest of which measured fifty-four and a half inches in length of top shell over the curve. Tortoises were recorded at that time as "fairly common" on Indefatigable Island. The Norwegian settlement on this island, recently abandoned, must have killed many tortoises as we found numerous large skeletons during our brief stay in the tortoise country. The trail to this region had been kept fairly passable by the two Norwegian survivors who were our guides. Tortoise meat was still an important part of their food supply and tortoise oil served them as butter. They informed us that young tortoises were seldom found. A four-pound specimen represents the only small tortoise we obtained. The Galapagos hawk, which is more abundant on Indefatigable than elsewhere, was credited with destroying newly hatched tortoises. It is possible, since tortoises are no

The Director nooses the unwary hawk. Indefatigable Island.

longer abundant, that hawks serve to hinder their increase on Indefatigable. It appears that hawks are less numerous on Albemarle Island where tortoises are more in evidence.

The ancestor of the giant tortoises that once swarmed on the Galapagos Islands remains unknown. It was probably a mainland form now long extinct. The island descendants reached large size and great numbers because of an abundant food supply and the absence of enemies.

We have recently learned that the Crane Expedition of 1929 got specimens of *Testudo porteri* which are now in the zoological gardens at Chicago.

Two specimens of the Hood Island tortoise (*Testudo hoodensis*) until recently believed to be extinct, were obtained by the Pinchot Expedition of 1929 and brought alive to this country.

Marine Iguana[6]: — This remarkable species is peculiar to the Galapagos. It is found on all rocky shores of the archipelago, being perhaps more numerous on Narborough and the adjacent shores of Albemarle, than elsewhere. Marine iguanas are only to be seen close to the water, lying on the warm rocks, often in large companies. While they feed chiefly on sea weed, they do not venture far from the rocks, with which their dark colors are in harmony. Other observers have found their remains in sharks, which are abundant among the islands. Judging from the numbers of iguanas to be seen in some places, it is unlikely that destruction by sharks is of serious extent.

Large marine iguanas are about four feet in length. Their eggs are buried in the sand. We obtained a smaller variety (*Amblyrhynchus nanus*) inhabiting Tower Island. Slevin records that marine iguanas are very rare on Chat-

Mr. Hay finds a tortoise. Indefatigable Island. Photograph by Kermit Roosevelt.

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[6] *Amblyrhynchus cristatus.*

Fearless sea lions (*Otaria jubata*).
South Seymour Island.

ham Island where the natives formerly ate them and their eggs.

They have not been observed at Charles Island by recent expeditions. There was formerly a large colony of Ecuadorians on this island, which may account for their present scarcity there. The abundance of sharks in Galapagos waters doubtless serves to restrict the movements of iguanas from one island to another.

Specimens kept in sea-water pools in the New York Aquarium always swam with their legs close to the body, the long, laterally-compressed tail furnishing the swimming power. Marine iguanas have never fed in captivity although well supplied with sea weed.

Land Iguana[7]:—The introduction of dogs is largely responsible for the scarcity or actual extermination of this iguana on most of the islands. It is common on South Seymour where dogs have not been introduced. We obtained several specimens on that island but did not observe it on Indefatigable, where it is presumed to be extinct. They had little fear and were easily caught. This iguana has always been used for food by the natives. I found three burrows close together in the loose soil of a hill a mile south of Tagus Cove on Albemarle Island but saw no iguanas. The land iguana of Barrington Island, where it is now rare, has been described as a distinct species. Our live iguanas were fed on the leaves of several kinds of bushes that were brought on board. They are much heavier bodied than marine iguanas of the same length. Unlike the marine species they are savage biters and must be handled carefully. Large specimens may exceed three feet in length.

Flightless Cormorant[8]:—This bird, the various species of penguins and the "steamer" duck, are the only existing sea birds that lack the power of flight. The distinction is a dubious one, tending toward the fate that befell the equally flightless great auk of the north.

The flightless cormorant is probably a disappearing species. Its present distribution is limited, so far as known, to Narborough and the adjacent shores of Albemarle Island. It is possible that it had a wider range before the discovery of the Galapagos Islands. We know nothing of its former distribution as it was not noticed by naturalists until described in 1899. The introduction of dogs by Ecuadorian settlers early in the nineteenth century may have contributed toward its present limited distribution. Narborough Island is still free from the pest of wild dogs that afflicts the southern part of Albemarle and other islands of the archipelago. The flightless cormorants now in the Aquarium were captured in Tagus Cove, Albemarle, with dip nets. The birds sit stupidly on the rocks until the boat is so close that escape is impossible.

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[7] *Conolophus subcristatus.*

[8] *Nannopterum harrisi.*

While searching for penguins, I examined several miles of rocky shores north and south of Tagus Cove and also on Narborough. While no count was made, I must have seen as many as fifty. Not more than three were found in any one place. We disturbed none except those captured in Tagus Cove. No nests were observed. It would be interesting to know how many are in existence.

Mr. Astor captures land iguanas. South Seymour Island.
Photographed by James P. Chapin.

It may be more numerous on the western part of Narborough which is as yet unexplored zoologically.

The behavior of the flightless cormorants now in the New York Aquarium is interesting: When one of these birds rests on its breast, it often goes to sleep with the long neck stretched out flat on the platform. The attitude often creates the impression that the bird is dead.

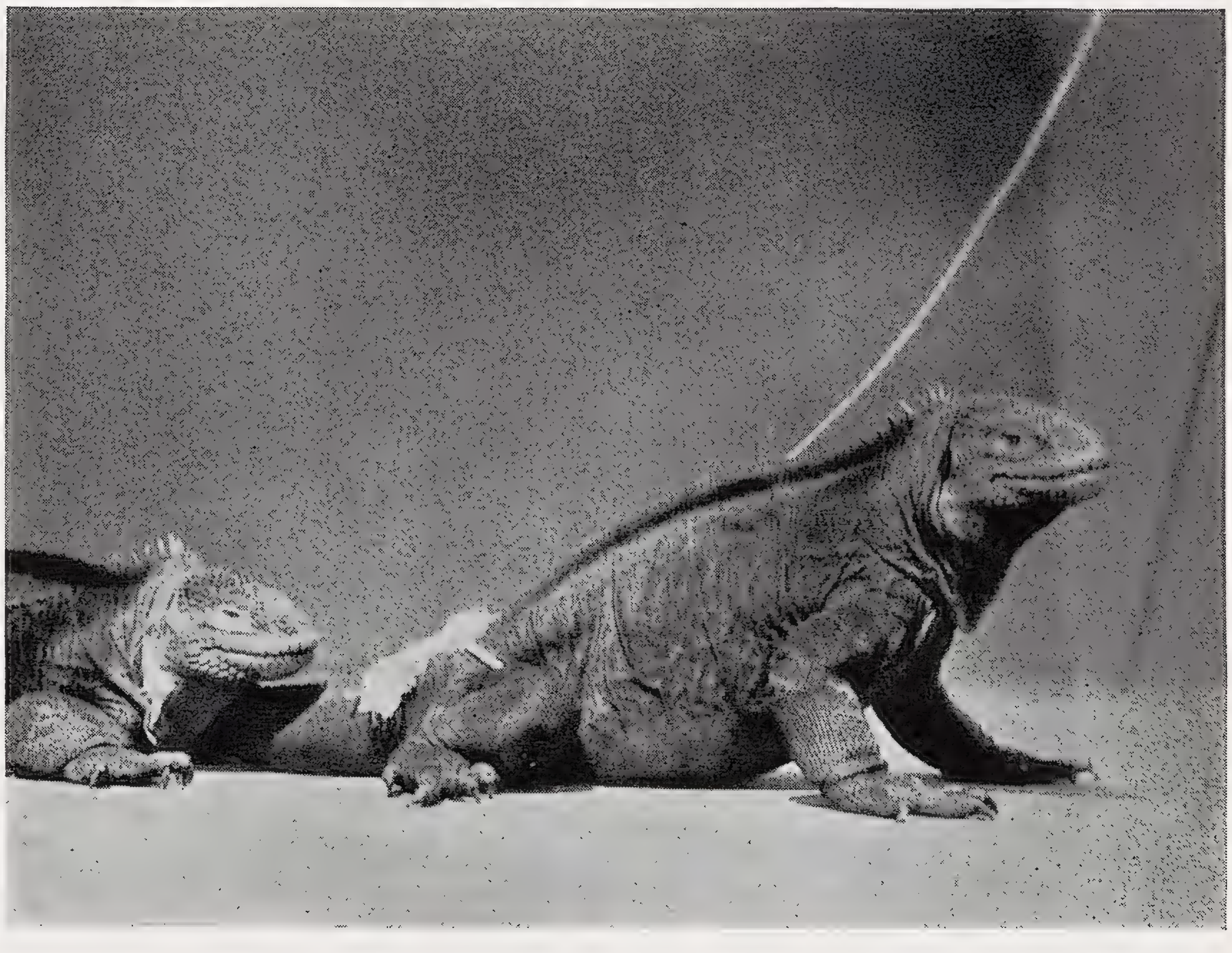
Messrs. Hay and Astor would persuade the land iguana that bananas are edible.

Galapagos Penguin[9]:—The engaging little penguin is found on most of the islands. Naturalists have observed it in larger groups at Iguana Cove, Albemarle Island, than elsewhere. Our specimens were captured at Tagus Cove and along the shore a mile south of the entrance.

Little is known of its nesting habits. Two adults and two young were taken on April 7, in a cave which could be entered only by a boat. The necks of the young were covered with down. They were evidently still being fed on regurgitated food and refused the live minnows so eagerly taken by their parents. It seems probable that they were hatched early in March and that they had not yet taken to the water. Both adults and young were found on a steep ledge inside the cave which the latter were not yet able to descend. The young birds soon became thin and did not survive on the forced feeding that was resorted to. The adults were tame and continue to be so in the Aquarium, where they are very active in the capture of live minnows thrown into their large pool. The nearest relative of this bird is the Chilian penguin of southern South America.

Forked-tailed Gull:—The original example of this bird was obtained long ago by Neboux of the French frigate *Venus*. The species remained unknown in American museums until the first voyage of the *Albatross* to the Galapagos, where I secured six specimens. Others have been collected since.

The two live birds, brought to the Aquarium by the *Nourmahal* appear to be thriving under the conditions of captivity. The species was found in greater numbers at Tower Island than elsewhere in the Galapagos, perhaps because the



Land Iguana (*Conolophus suberistatus*). Indefatigable Island. Photograph by Kermit Roosevelt.

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[9] *Spheniscus mendiculus.*

Inquisitive Pelican (*Pelecanus californicus*). Indefatigable Island.

Galapagos hawk is not found there. Our specimens were caught with a dip net while engaged in a fight so strenuous that our approach was entirely disregarded.

Galapagos Hawk[10]:—The Norwegian colonists that lived on Indefatigable Island for a few years found it almost impossible to raise poultry because of the abundance of hawks. Specimens of both dark and light phases of plumage were preserved and seven were brought alive to the Zoological Park. The latter were fed with the bodies of other hawks killed for the purpose. We did not observe hawks on either Charles or Tower Islands. Their fearlessness and curiosity are surprising in view of the numbers that have been killed by the Norwegians.

Galapagos Rail[11]:—This is a common bird in the moist region of Indefatigable where it runs under the low shrubbery. Being rather fear-

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[10] *Buteo galapagensis.*
[11] *Creciscus spilonotus.*

The Nourmahal in Tagus Cove, Albemarle Island.

Tuna fishing off Tagus Cove.

less, rails were not difficult to secure. The species of Indefatigable has been described as *Creciscus sharpei,* but may not be distinct.

Galapagos Pintail Duck[12]:—This species was obtained in a pond in the tortoise country several miles northwest of Academy Bay, Indefatigable Island. A small flock was seen in a lagoon, near the bay. It is found on all the islands where there are fresh and salt ponds. Little is known of its nesting habits. It does not seem to be numerous anywhere and being unwary, may have an enemy in the Galapagos hawk. In taking specimens, no heavier ammunition was required than the load of small shot from a smooth-bore collecting pistol.

Finches: — The remarkable black finches of this island number about ten species. They are most numerous within four or five miles of the coast and practically disappear at altitudes about fifteen hundred feet. All of

First Officer Carlson and the Director set fish traps.
Tagus Cove, Albemarle Island.

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[12] *Pœcilonetta galapagensis.*

Mr. Carlson pursues a penguin with dip net. Albemarle Island.

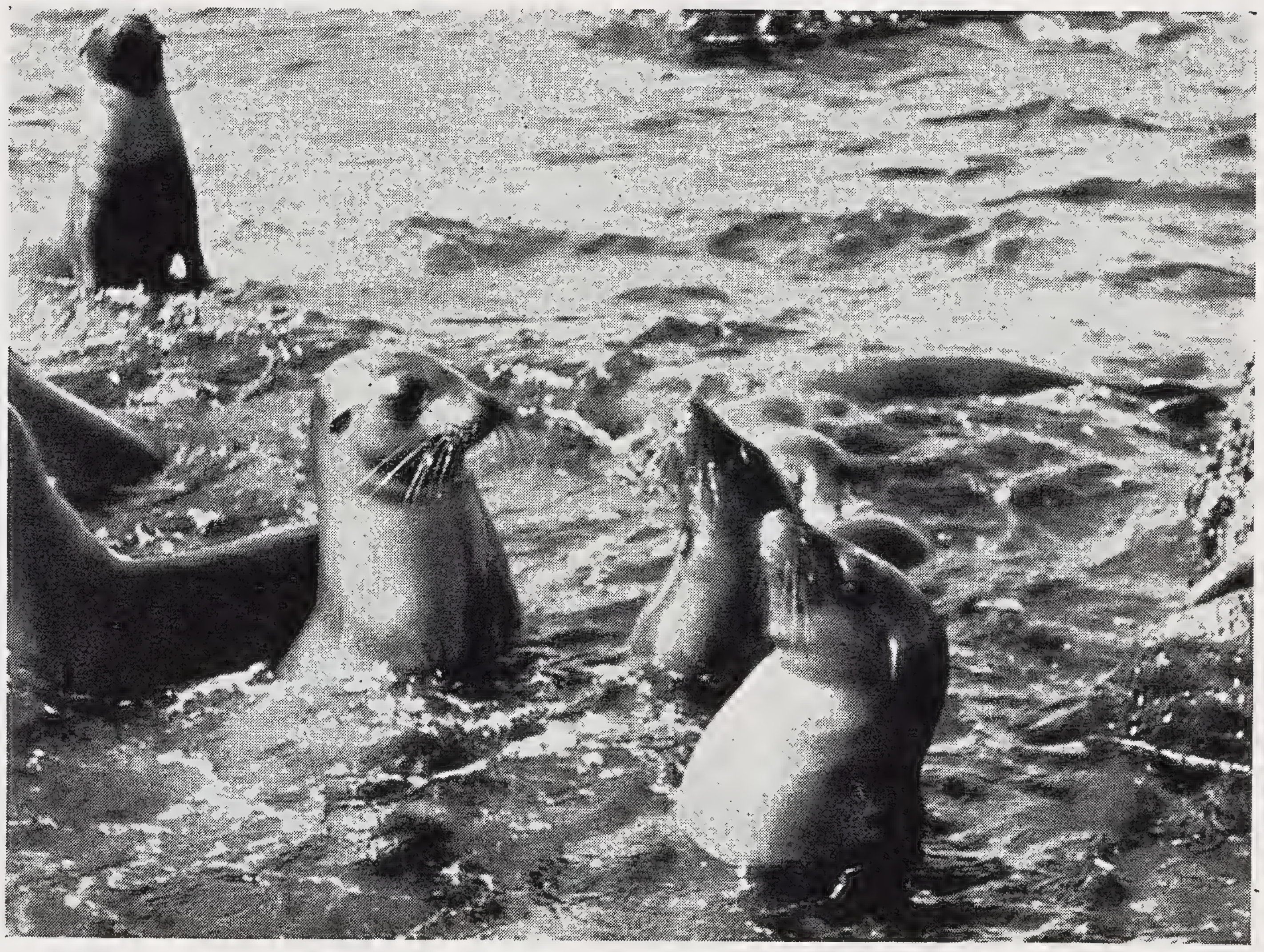
the Galapagos finches build bulky domed nests with side entrances. There are thirty-five or more species of these finches in the Galapagos group. According to most authorities, all are of the genus Geospiza, although some have divided them into four sub-generic groups. Some occur on more than one island where they are represented by sub-species. The following are found on Indefatigable: Geospiza pallida, G. prosthemelas, G. psittacula, G. crassirostris, G. parvula, G. fuliginosa, G. fortis, G. strenua, G. scandens, G. giffordi.

The last word has not been said on the classification of the Galapagos finches. The largest collection of specimens, that of the California Academy of Sciences, is now being subjected to critical study and the status of the birds of this puzzling group may be made clearer.

Other Birds:—Among the indigenous land birds taken on Indefatigable were the following: Flycatcher (*Myiarchus magnirostris*); Red Flycatcher (*Pyrocephalus nanus*); Creeper (*Certhidea olivacea*); Martin (*Progne modesta*); Black-eared Thrush (*Nesomimus melanotis*) Short-eared Owl (*Strix punctatissima*); Pigmy Barn Owl (*Asio galapagensis*); Dove (*Nesopelia galapagoensis*).

Reptiles: — Aside from the large marine iguana (*Amblyrhynchus cristatus*), the only other lizard obtained on Indefatigable was Tropidurus albemarlensis. We did not find the gecko lizard (*Phyllodactylus galapagoensis*). Specimens of the small snake of this island (*Dromicus steindachneri*) were secured. All of the Galapagos snakes are harmless species. I carried one by the tail for some distance, which held tightly to the live lizard in its jaws.

Mammals:—In the Galapagos Islands, indigenous mammals are represented by bats and



Sea lions cheerfully pose for the camera man. South Seymour Island.

Captain Klang studies the head of a marlin swordfish, Cocos Island.

small rodents only. The native rat of Indefatigable (*Nesoryzomys darwini*) was found in abundance about a hut a few miles back of Academy Bay.

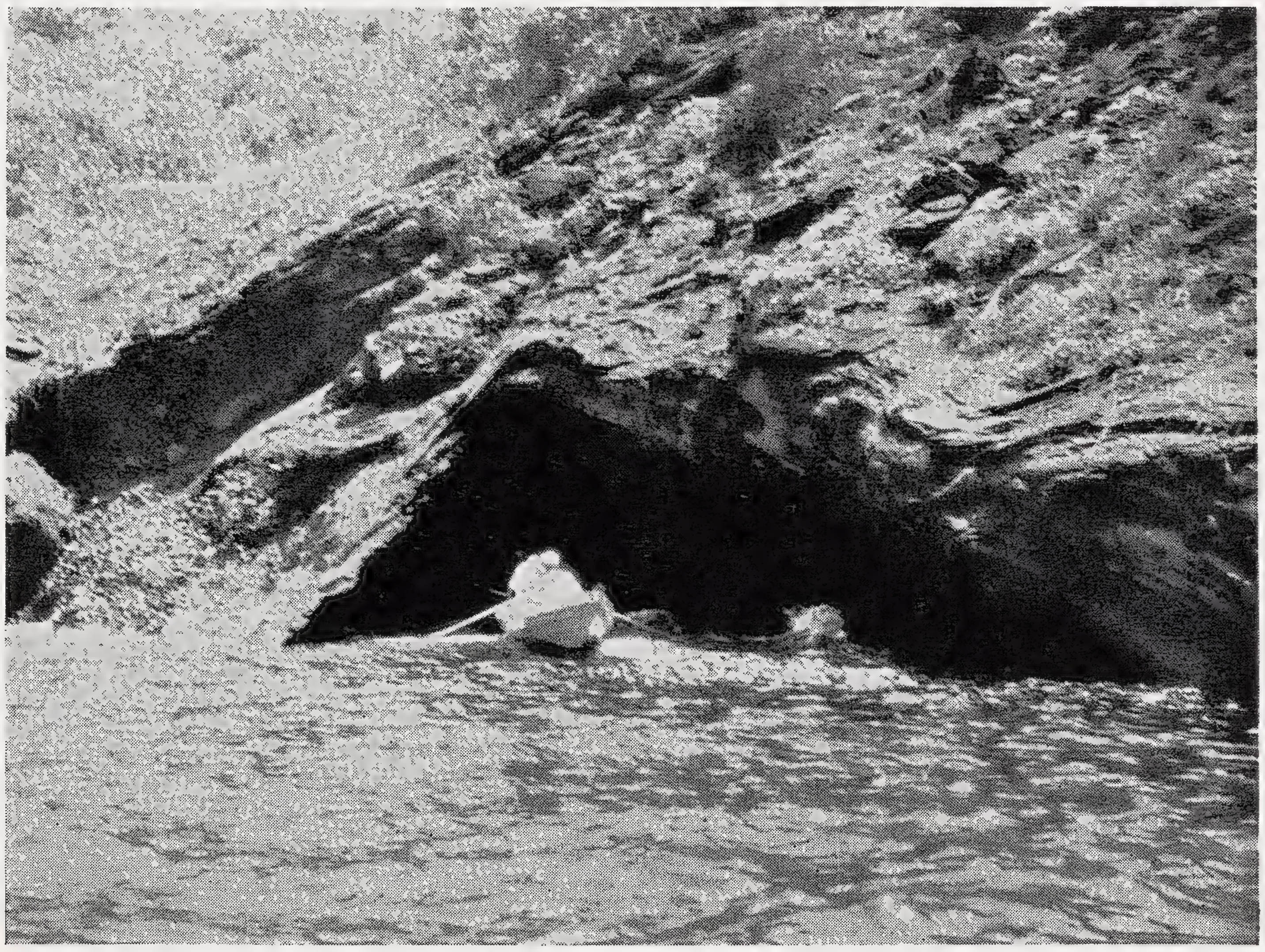
All students of the animal and plant forms of the Galapagos Islands are in agreement that they were originally derived from the Americas.

Fishes:—Among the live Galapagos fishes in the Aquarium, the following species are recognizable: *Dermatolepis punctatus, Paralabrax albomaculatus, Archosargus pourtalesii, Pomacentrus leucorus, Bodianus eclancheri, Canthidermis angulosus, Balistes verres, Melichthys bispinosus, Spheroides annulatus, Trachinotus rhodophus, Evoplites viridis, Xenocys jessiae, Xenichthys agassizi, Orthopristis chalceus, Epinephelus labriformis, Pomacentrus* sp., *Halichoeres* sp., *Haemulon* sp., *Muraena* sp. There are doubtless some new species which cannot be studied at present.

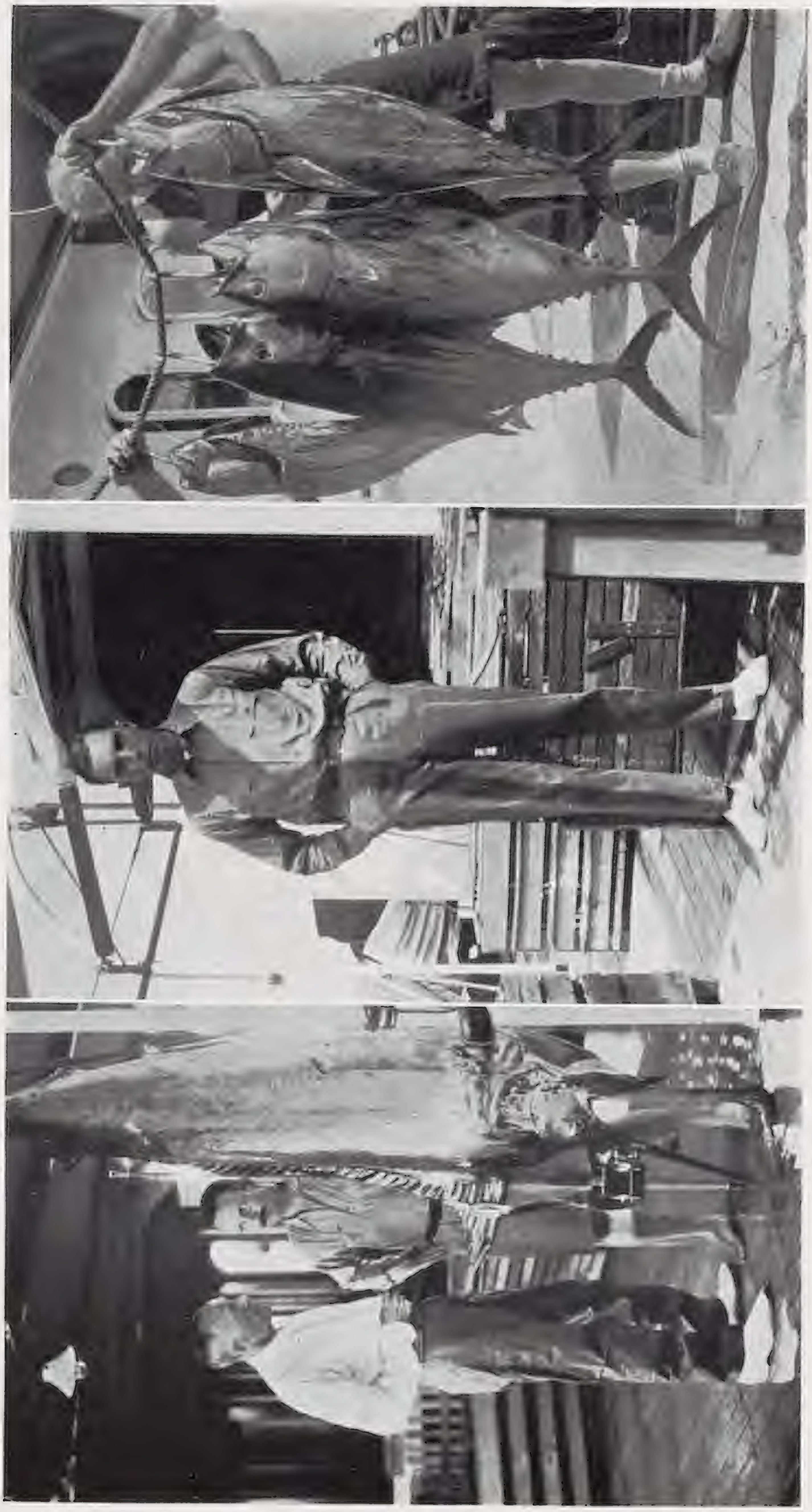
There are as yet only a few papers on Galapagos fishes. The species already known have been taken chiefly by seine, hook and line. Extensive collecting by the use of wire fish traps should yield an abundance of unknown fishes. The light, wire fish traps used by the Astor expedition were not so constructed as to prevent the entrance of small sharks that often either ate or mutilated the catch. Traps properly constructed for use in these waters would undoubtedly yield a rich harvest to the ichthyologist.

Other Islands Visited

Albemarle Island—Tagus Cove:—The time spent here was profitable in many ways: One of the wire fish traps brought up eighteen specimens of a *Scyllaris,* which we recognized as something new. The genus had not pre-



Cave where young penguins were found. Albemarle Island.



1. The Doctor inspects Roosevelt's marlin swordfish. 2. The Commodore inspects the menagerie on deck. 3. The Tuna Fishers display their catch. Photograph by C. L. Hay.

The Inquisitive Hawk (*Buteo galapagensis*)
Indefatigable Island.

viously been reported from the Galapagos. It is strikingly different from the so-called "Locust Lobster" of the West Indies, which we have often kept in the Aquarium.

Upon climbing a high hill, a mile or more south of Tagus Cove, we found a vast, steep-walled crater perhaps nearly two miles in diameter, containing a large salt lake. The sea had entered where the western wall was broken down and a later flow of lava from some point to the southward had covered the space between the crater and the sea, forming a lake. The black lava field extended southward for miles with no vestige of plant life

Marine Iguanas (*Amblyrhynchus cristatus*). Narborough Island.

in sight. In the lake which was of briny saltness, we obtained small fishes of the genus *Xystaema*. These appear to be young, the largest being 1½ inches long. The shore line of the lake bears no evidence of rise or fall of tide.

This crater lake is briefly described by Stewart in his "Botanical Conditions on the Galapagos." He considers it identical with the one referred to by Darwin as located near Banks Cove. The crater, the salt lake and the vast lava field form a truly impressive sight.

Tower Island:—The day spent in Darwin Bay at Tower Island proved to be an interesting one. A single fish trap caught nineteen specimens of the large spiny lobster (*Panulirus penicillatus*), the first we had seen. Two fork-tailed gulls (*Creagrus furcatus*) and a single dwarf marine iguana (*Amblyrhynchus nanus*) were captured. The botanist was the only member of the party to visit the inland crater lake of Tower Island. This lake was first described by Prof. Alban Stewart who visited Tower Island as botanist of the California Academy of Sciences Expedition in 1906.

Darwin Bay where the *Nourmahal* anchored, is a deep, sea-filled crater, bordered for the most part by high vertical cliffs. It is of even more interest than the crater anchorage of Tagus Cove. It was unfavorably known to the whalers who went there before the middle of the last century in search of tortoises but never found any.

Charles Island:—The *Nourmahal* anchored for a short time at Blackbeach Road for the purpose of securing specimens of an entirely spineless cactus discovered there by the writer in 1928. The large group of this cactus had entirely disappeared and the loose earth about it had become a rolling place of wild donkeys. It was not even possible to get cactus roots. The spineless cactus may have been originally abundant on Charles Island where there was a settlement of Ecuadorians nearly a hundred years ago. It is possible that it has been exterminated by the numerous wild cattle and donkeys whose ancestors were introduced at that time. The writer had requests from Arizona and southern California for information respecting the cactus as a forage plant and greatly regrets its disappearance. Fortunately, the plants he secured in 1928 and left with the Department of Plant Industry at the Canal Zone are growing and may later be available for cultivation. Our search for other masses of this cactus was extended over a wide territory without success. It may be rediscovered by future explorers in some rough territory in this island that is not accessible to wild cattle and donkeys.

Salt Lake in great crater, Albemarle Island. Two miles south of T

Cocos Island:—This fascinating and at present, unhabited island was visited during the return voyage. Our collectors secured representatives of the few peculiar birds and reptiles existing there.

Unlike the nearly waterless Galapagos it is densely covered with tropical vegetation to its greatest heights and has strongly flowing brooks. It was the abundant supply of fresh water that attracted the many nineteenth century whaling vessels whose names are carved on the rocks about the watering places. It was easy to identify most of them as whalers, from numerous whaling records in my possession.

One inscription was that of *H.M.S. Bellerophon* 1817, the warship on which Napoleon sought refuge. There were names of men from New Bedford, Nantucket, Boston, Marblehead and other early whaling ports. There were also the names of a few warships.

r more than a mile in diameter. Black lava flow in foreground.

After leaving Cocos Island the *Nourmahal* stopped for a day's fishing at the Perlas Islands, off Panama and the Tortugas Islands off Florida.

The cruise of the *Nourmahal* to the Galapagos, commenced at Miami, Florida, on March 23, was finished at New York on May 2. Practically all of the objects for which the vessel sailed, were attained. The return to New York marked the conclusion of a voyage during which the members worked together in harmony, enjoying all the facilities afloat and ashore, that an interested and generous host could provide.

Messrs. Roosevelt, Cutting and Hay, all experienced explorers, took hold of the mountain work with energy. Mr. Astor, Dr. Pool and Mr. Huntington caught tuna and other large oceanic fishes in numbers, more than sufficient for the entire ship's company. Dr. Svenson's piles of pressed plants and Dr. Chapin's cases of bird skins testify to their activities. Messrs. Bronson and Sanborn, assisted at times by others, produced with brush and camera a wealth of illustrative material, of which only a mere fraction appears in this Bulletin. Captain Klang and the officers and crew of the *Nourmahal* rendered most efficient help whenever called upon. The writer cherishes warmly all memories of the voyage of the *Nourmahal* and the hearty company on board.

Preservation of the Galapagos Fauna:—An attache of the Consulate of Ecuador in New York has requested my opinion as to what steps should be taken by the Ecuadorian government for the preservation of the animal life of the Galapagos Islands. Several parties of naturalists have visited these islands during recent years, with the result that the forms of life indigenous there have become more generally known.

The gentleman also made inquiry as to whether a scientific association, such as the New York Zoological Society, would be interested in undertaking the supervision of some method of conservation that might be found desirable. It is true that the animal life of these islands is of world-wide scientific interest, although at present of no commercial value.

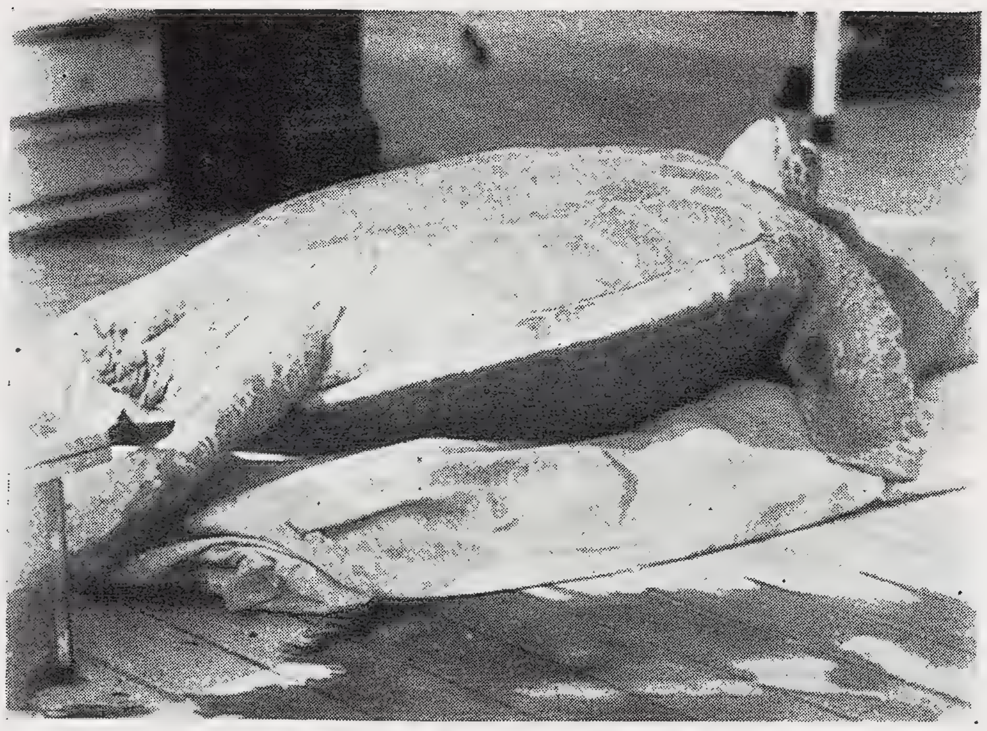
The giant land tortoises from which the islands derived their name were originally so abundant that they constituted an important food resource for more than two centuries, when the natural supply became exhausted.

The peculiar fur seal (*Arctocephalus philippii*) of the Galapagos Islands, also formerly abundant, is probably near extinction as none have been seen during recent years. There are before me a few records accounting for 17,485 fur seals taken at the Galapagos Islands between 1816 and 1897. The numbers taken since 1887 have been small. It is known that large numbers were killed during the early part of the nineteenth century. Fur seals were found about most of the islands and many were killed in caves.

The land iguana which is still used for food has disappeared from several of the islands.

The marine iguana, also a food species, is now rare about islands long inhabited.

There is little doubt that the confiding land birds have suffered diminution in number as the result of the introduction of cats. Their fearlessness renders them an easy prey and their nests are as a rule in low shrubs. The large-billed finch, one of the most interesting of the finches of Charles Island has not been found since it was discovered by Darwin in 1834. The introduced pigs, dogs, cats and rats now abundant in the wild state, have affected the native birds and reptiles to a serious extent.


Pacific Green Turtle (*Chelonia virgata*), Narborough Island. Now in N. Y. Aquarium. Photograph by C. L. Hay.

The difficulties attendant upon the reduction of these pests would be very great. The islands most afflicted by them are large, rugged and nearly waterless. It is possible that tortoises would increase in numbers if the pests that devour their eggs and young could be held in check by poisoning, shooting and trapping.

An important move for the preservation of tortoises would be prohibition of their removal from the few islands where they are still to be found. This is especially desirable in the case of Duncan and Hood islands, where few remain. These islands, never inhabited, are still free from enemies of tortoises. The two distinct species belonging to Duncan and Hood islands should be preserved for the double purpose of

Marine Iguanas (*Amblyrhynchus cristatus*). Narborough Island.

Flightless cormorants. Narborough Island.
Photograph by C. H. Townsend.

their value as food animals and their scientific interest.

The extinction of an animal useful to man is always deplorable. After the early navigators, the buccaneers, the sealers and the whalers, working through a long period of time, had exhausted the more accessible supplies of tortoises, the making of tortoise oil was continued by the settlers. Their practice was to remove the fat only, rejecting the carcasses, being unable to utilize any large number of food. In many places in the interior the ground is covered with the whitened shells of great numbers of tortoises killed for this purpose.

If the exportation of tortoise oil from Albemarle Island were prohibited the supply of tortoises available for food might be preserved indefinitely for the use of the natives.

The tortoise of Charles Island (*Testudo galapagoensis*) has long been extinct. This island could readily be stocked with tortoises from Albemarle Island (*Testudo vicina*). Charles Island is at present uninhabited. Being less than ten miles in diameter and having fresh water springs not difficult to reach, it would probably be the most desirable island of the group for a wild life refuge. Objections to other islands would be their large size, and the difficulty of protecting them and controlling introduced pests, the lack of water on smaller islands, and the presence of settlements on others.

Briefly, methods of conservation should include protection of all remaining species of tortoises, the prohibition of sealing, the introduction of the land iguana on islands where pigs and dogs do not exist, the protection of the flightless cormorant and the penguin, and the control of pests.

Flightless Cormorants (*Nannopterum harrisi*). Narborough Island.
Photograph by C. H. Townsend.

The Commodore cuts down cactus leaves for tortoise food.

The Mountain Party on Indefatigable Island

Kermit Roosevelt

ONE of the objectives that Dr. C. H. Townsend had suggested for the Nourmahal Galapagos Expedition was the penetration of Indefatigable Island, the interior of which was practically unknown.

Four years ago at the instigation of the Norwegian Consul in Guayaquil, a party of some thirty-five Norwegian settlers came out to the Galapagos with the purpose of establishing a fishing industry, using Indefatigable Island as their base of operations. For one reason or another, all save two of the colonists have left the Island. Most of them have obtained work on the South American Continent, only a handful have returned to Norway.

The two men that have remained are still engaged in fishing, and in spite of the remoteness of their market (for their fish is disposed of in Ecuador) they are doing better than they feel they could do in Norway.

Dr. Townsend had planned landing at Academy Bay in the hope of securing the assistance of any of the possible remnants of the Norwegian colony. It was determined that the interests of the Expedition could best be served if, in addition to Dr. Townsend, Messrs. Hay, Chapin and Svenson should also land, so that they might make a reconnaissance of the Island in entomology, ornithology and botany, their respective specialties.

Cutting and I went ashore with them in order to cut out trails to the interior, and to do any other work which would have as its purpose enabling the naturalists to put in the maximum amount of their time collecting, and a minimum amount of unremunerative tasks.

When we landed, we found the two cabins and the fish cannery which the Norwegians had built were deserted. We had no method of telling when they had last been occupied, or

On the trail to the tortoise country. Robert Huntington, foreground, and the Norwegian fisherman.

where their owners might be. We had heard, however, that three or four miles inland there was a plantation where the colonists grew fruit and vegetables. After casting about, we struck a trail which appeared to go in a direction that might lead to the plantation, so Cutting and I decided to follow it.

Water presented an awkward problem, for on Indefatigable you were entirely dependent on rain. From the *Nourmahal* a supply had been landed in carboys. We also found a good deal of water in rain butts which had been placed under the eaves of the cabins by the Norwegians. This water, however, was only suitable for cooking purposes.

Armed with machetes and with our canteens slung over our shoulders, we set off along the trail. Much labor had been spent in its construction, for it pursued an undeviating course through one of the most uncompromising bits of jungle it has ever been my lot to see. Huge boulders of volcanic rock lay in confused masses on either hand. Cactus of different varieties was interspersed between them, while the tangled mass of creepers and miconium presented a barrier through which one could only have proceeded at the veriest snail's pace were it not for the trail. In several places there were fissures in the rock. Dropping stones into them, we found them to be of great depth. No air circulated, and within a few minutes we were as drenched as if we had plunged into the sea.

After traversing this low coastal jungle for half an hour, we ascended an abrupt escarpment and for the first time were able to see farther than a few feet on either hand. Looking back we caught a glimpse of the sea and its nearness formed a disheartening commentary on the speed, or lack thereof, with which we had been traveling.

The jungle now opened out and there were pleasant glades with great trees. In another half hour's walking, we practically passed out of the cactus belt and found ourselves in a miconium forest. Along the trail we twice came across bits of tortoise shell, encouraging us to believe that one of the main objects of the landing party stood a fair chance of attainment.

We had got a late start, so the shadows soon began to lengthen and we realized that unless we were prepared to pass a waterless night in

A rest on the way to the tortoise country.

Refreshment along the way.

the jungle, we would have to turn about. We had proved nothing, for we could find no trace of anyone having recently passed over the trail.

By the time we got back to the coastal belt we had become unpleasantly aware of the presence of mosquitos, and when we rejoined our companions we found them busily engaged in repelling attacks. The insects increased in numbers momentarily, and we hurried through a very brief supper.

To add to our miseries, we had not been able to take any steps toward rigging our mosquito nettings, and we now found that the cabins were deficient of any sort of appliances to aid us. It is not difficult to foretell an unpleasant night. Cutting, as he crawled into his blankets, happened to pick out from among the folds by the light of his electric torch the most enormous centipede I have ever seen. He measured fully six inches. With great skill Hay introduced him into one of his collecting tubes, but the incident left each of us with rather an uncomfortable feeling of possible bedfellows. I pitched my net outside until I was driven in by a sharp shower, and I am certain that the combined sleeping of all seven of us would not have amounted to a reasonable night's sleep for one of us.

The next morning we set out again. Hay and Svenson volunteered to accompany us and bring a large canteen of water which could be left on the trail, so that if we pushed on and found no water, we would have something to fall back upon. We went along for half an hour beyond the point which we had reached on the previous day, and then our companions turned back. Chapin continued with us, and within an hour we came out into a clearing. Never have I seen larger banana trees nor more luxuriant sugar cane; indeed everything seemed to thrive. There were papaya and guava trees; coffee also appeared to adapt itself most excellently to the conditions. The first living thing to greet us was an old roan pony who quite obviously had thrived on his diet of bananas and sugar cane.

We threaded our way through the plantain grove. I was in the lead when of a sudden I caught a fleeting glimpse of an Indian dodging off into the shelter of a clump of banana trees. I shouted to him in Spanish, proclaiming the

Doctor Pool bandages a sprained ankle in the tortoise country.

Doctor Pool uses a rope to measure the circumference of a tortoise too heavy for transportation.

fact that we were friends, and rather sheepishly he came forth.

He had not spoken to anyone for a good many days, and as he afterward explained, the Norwegians knew so little Spanish that any conversation he held with them was of necessity very primitive. His name was Elias Sanchez, and he had spent thirteen years on Chatham Island. Why he had originally come to the Galapagos Islands we discreetly forebore to inquire. Ecuador has used the Islands to some extent as a penal settlement, and the old rule concerning curiosity that holds good in so many frontier communities, is well worth observing.

When once friendly relations had been established, the flow of Elias's Spanish knew no bounds, and he supplied us with much interesting information. First and foremost we inquired for the whereabouts of the Norwegians and were told that they were away fishing. Sanchez believed that we could find them along the shores of Barrington Island lying some fifteen miles off of Academy Bay.

We had abandoned the heavy packs that we were carrying a number of miles back in order to make better speed in our search for the plantation. Chapin was suffering from a cramp, so Cutting, Sanchez and I returned for the loads after refreshing ourselves with some stalks of sugar cane and a few bananas.

The trail was much overgrown, and it was no light task stumbling along under the weight of our packs. It was dusk when we reached the single room cabin that the Norwegians had built as their country residence. It stood on ten foot stilts, and in the open space below Sanchez conducted his kitchen. He was living on the land, which meant a fruit diet, but he did have with him a sack of coffee. He roasted some beans and made a brew of what he called "mountain coffee." It was black and bitter, but I never remember enjoying a cup more. We found the attention of the mosquitos in the cabin distinctly disagreeable, but Sanchez told us that once we were upstairs we would be free of them. During the course of our ascent, Cutting fell through a step near the top, for the wood was badly dry rotted.

Although at first exceedingly skeptical, we found Sanchez's prediction true, for in spite of the fact that the moonlight streamed through

Too big to be carried away. In the tortoise country, Indefatigable Island.

the chinks and knot holes, so long as we kept the door shut no mosquitos entered. Cutting, although unable to offer any explanation, said that he had noticed the same phenomenon before, and could only hazard the remark that mosquitos were conventionally minded.

The next morning we had a chance to see the plantation, and to fully appreciate the luxuriant growth. The soil must be immensely rich, depending as it does entirely upon rainwater. In addition to bananas and plantains and sugar cane, there were papayas and guava trees. The oranges were not yet bearing, and Sanchez was engaged in clearing away the jungle from among the coffee bushes which he said would bear in a twelvemonth. A family of pigs was living in the banana grove and appeared to thrive on their fruit diet. Some chickens had been introduced by the Norwegians, but they were far more wild than the island birds and were so lean and scrawny that, as Sanchez pointed out, no one would wish to eat them in any event.

Sanchez in everyday dress. Ecuadorian helper in tortoise collecting—

"The uniform 'e wore
Was nothing much before
and rather less than 'arf
of that behind."

Photograph by Kermit Roosevelt.

Sanchez was very scornful of the Norwegians' qualifications as farmers. He said that they might be all right as fishermen, but they certainly knew nothing about the soil and were quite useless when they tried to help him in getting the plantation into shape.

As far as we could see, about the only tool he had with which to carry on his agricultural labors was a machete. In the back blocks of South and Central America the machete means to the native what the camel does to the desert Arab or the yak to the Tibetan. He needs no beast of burden for transport or for food. With his machete he hacks his way through the jungle and fells the palm tree for food, or plants his mandioca in the little clearings.

Having started back to the Coast, the last sight we had of Sanchez he was busy clearing away the heavy jungle that had swarmed in upon the coffee plants and would soon, if not checked, have once more reclaimed from man the whole of the little plantation.

Hay had christened the small settlement on Academy Bay as "Hangman's Rest," because of a gibbet-like derrick at the landing, and when we got back there we found that our companions had been having a very lively time of it with the mosquitos. Long before dark they would come out in their myriads and from then until well on in the morning living was not worth while. The different types of mosquito oil which we possessed seemed only to stimulate their appetites.

It had been arranged that the *Nourmahal* would return to learn what progress had been made, and the next day at noon she arrived. We set off immediately to look for the two Norwegians and found them just where Sanchez had predicted they would be. They were sailing in a small boat that had been brought out from Norway by the Expedition. Taking their craft in tow, we returned to Hangman's Rest.

The two men were lean and sunburned. They had been living very light and our advent was most welcome. Neither of them spoke enough

English to be of much assistance, but one did speak a little Spanish, and while we were on board the *Nourmahal,* there was no lack of interpreters among the crew. Commodore Astor soon made arrangements that one of them should join us in the attempt at reaching the interior, while the other took Sanchez and went in search of tortoises.

It seemed better to give them both a comfortable night aboard ship before setting out. Their new found friends among the crew took them off and outfitted them anew. Even more than the cuisine of the *Nourmahal* the Norwegians enjoyed the beer we had taken on at Panama.

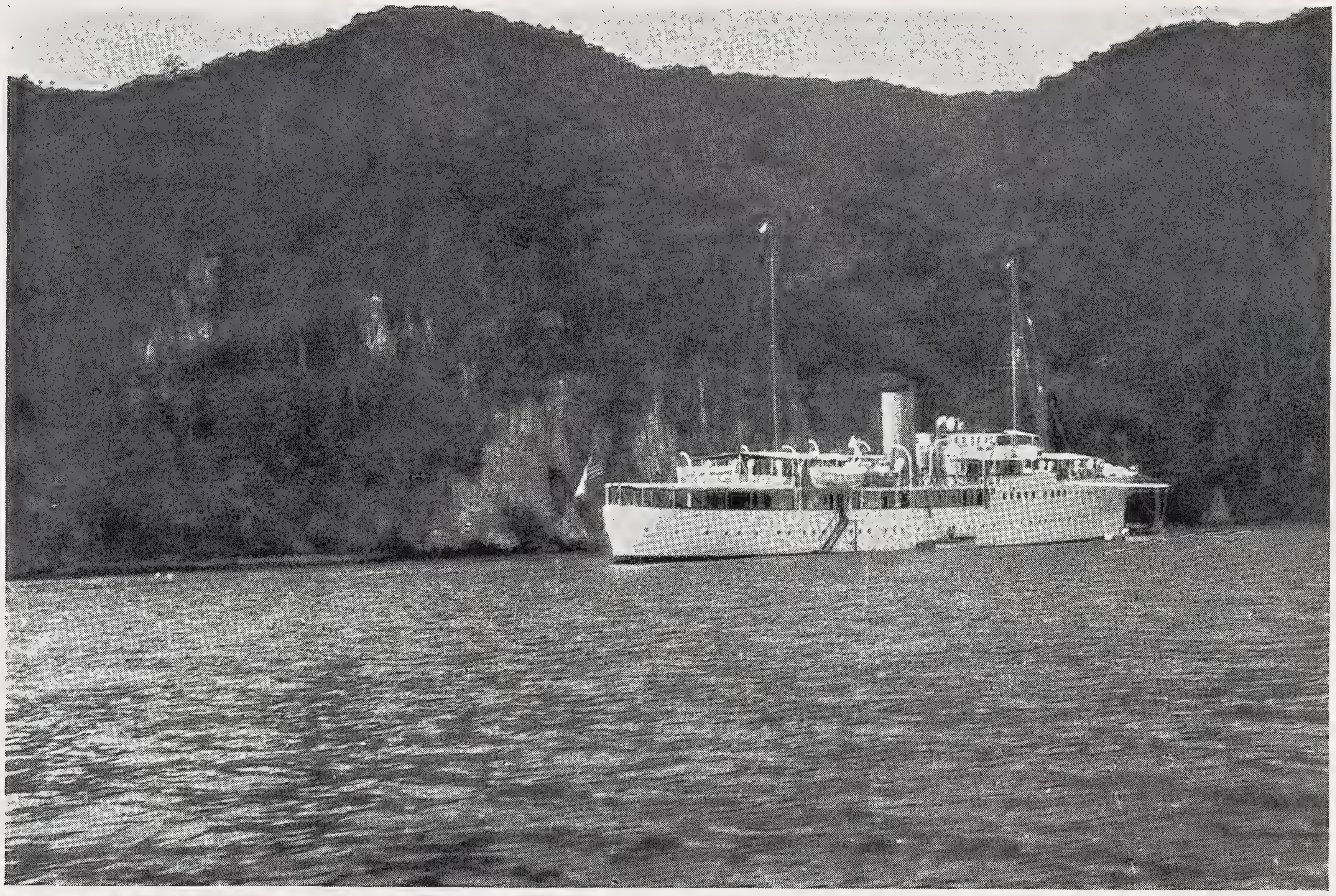
Our new friends, Edvardsen Stampa and Gordon Wold, assured us that they could take us into the tortoise grounds on the morrow, but warned us that it would be a long day's trek, nor were they wrong about this. An hour's walk along the trail to the plantation brought us to where we turned off for the "galapago" grounds, for Galapagos means tortoises and the natives when going off to kill these animals for their meat and oil, say they are going to "galapago."

It was easy enough to get lost, for you could only see a short distance in any direction, and everything looked exactly the same with no outstanding landmark of any description. Our friends told us that eight months previously a party of the colonists on Chatham Island had gone over and killed a number of tortoises. In blazing their way they had not stuck to the Norwegians' trail, so that we were soon in a maze of blazes, and then not long afterward, Hay recognized a tree which proved that we had made a complete circle. We would have been in difficulties had it not been for our compasses. Steering a course by these we hit off the pool of dark water which Edvardsen said was the center of the tortoise grounds. As we reached it, he pointed to one of the great reptiles making off through the undergrowth in cumbrous fashion. We could only estimate its weight, but we put close in the neighborhood of three hundred pounds. Cutting took some motion pictures and the rest of us tried our hand at stills. We could not linger long if we hoped to get back by dark, and the prospects of a waterless night in that jungle were not alluring. Before we had gone far, Astor slipped on a rock, giving his ankle a very nasty sprain. Fortunately he was able to hobble along on it, and when it got steadily worse Dr. Pool strapped it up enabling him to continue. It was seven o'clock by the time we reached the shore, and the flesh pots of the *Nourmahal* were thoroughly appreciated.

The next morning Astor sailed off in search of penguins and flightless cormorants and other fauna of the Islands, while the landing party returned to Hangman's Rest. Each man loaded on his back whatever he thought he would need in the way of food and equipment for the next five days, and we started off up the trail to the plantation, "Fortuna" the Norwegians called it. The farther we got inland, the less simple to navigate became the trail, and although we had cut down to the barest necessities, our packs were heavy. The first glimpse of the banana grove was a welcome sight. Sanchez departed for the tortoise grounds with the horse which we had seen on our first arrival, but Wold stayed with us.

There were two cabins at Fortuna, standing five or six hundred yards apart. No one had been to the farther one since the departure of the balance of the colonists, and so thoroughly had the jungle claimed its own that it took an hour's steady work with machetes before we hacked our way to the deserted hut. Four of us in line were wielding our machetes and the man behind me misgaged his distance, giving me a whack on the calf of my leg that I at first thought had half severed it, but some energetic first aid on the part of my companions set things pretty well to right.

The next day Chapin was busy collecting birds and Svenson was equally active making botanical specimens, while Cutting, Hay, Wold and myself set out to cut a trail up the mountain. It was very hard work, and most discouraging after toiling interminably to still hear the crowing of the half wild fouls at Fortuna. We followed up the dry bed of what in the rains is a raging torrent. The heat was suffocating,



The Nourmahal in Wafer Bay, Cocos Island.
Lofty cataract beyond foremast.

for no breeze stirred through the tangled vines and creepers.

At nightfall we were back with the others at the cabin. We found that it took us five times as long to hack our way through the jungle as it did to return over our trail for the same distance.

Both Chapin and Svenson had spent a successful day. What most strikes a visitor to the Galapagos is the lack of fear shown by the wild life of the Islands. Cooper's lines on the "Solitude of Alexander Selkirk" constantly run through your head

"The beasts that roam over the plain
My form with indifference see
They are so unacquainted with man
Their tameness is shocking to me."

It seems particularly strange that domestic animals such as goats and dogs and chickens that have gone wild should invariably be so wary of man, while the natives of the Islands show no fear.

The Galapagos hawks are particularly tame. We came up under them as they perched on branches of trees, and if you poked a pole at their feet, you could make them get off the branch on to the pole. I saw one sitting with a flycatcher and a mocking bird on branches close by in the same tree. This confidence was sometimes misplaced, for not long after I came upon a hawk devouring the remains of a mocking bird. We saw hawks stooping at chickens more than once, but judging from the ease with which the fowl evaded them, it must have proved a fruitless pastime for the hawks.

The two succeeding days we continued to hew our way up the mountain side, at length coming out on a ridge twenty-one hundred feet above sea level. Along the trail we saw many native mice and collected several snakes. The last day both Chapin and Svenson came with us and brought back what they found of interest in fauna and flora. We had constant showers which made it most uncomfortably slippery, but in compensation filled with water the holes in the rocks and relieved our anxieties anent thirst. The jungle teemed with mosquitos and it was a bedraggled and much bitten group that wended their way back to Fortuna from the last day's climb.

To add to our discomforts, we found that the pigs had in some manner got hold of the remnants of our supply of bacon, and with true cannibalistic propensity had made a meal of it. The next morning we gathered our scanty belongings, and with greatly lightened packs headed down trail for Academy Bay. That afternoon a grimy, unshaven, much bitten, and hungry landing party boarded the *Nourmahal* in a condition to whole heartedly appreciate its kindly welcome. The compassionate Townsend hurried ashore with a bottle of liniment to anoint the bruised ankles of the gallant pony that had carried the heavy tortoises so many weary and thirsty miles. Bidding the Norwegians and Sanchez good-bye, we upanchored and headed North with more than a twinge of regret to think that our visit to the Galapagos was at an end. Temporary discomforts are not long remembered when the rough country explored leaves the mind filled with matters of unusual interest.

Where the brook meets the sea. Chatham Bay, Cocos Island.
Photograph by Kermit Roosevelt.

The Vegetation of Indefatigable Island

Henry K. Svenson

THE fragrant breeze on approaching Indefatigable Island was an indication of our good fortune in arriving at the height of the flowering season. Though from a distance the coastal region, with its great cacti, had the same charred aspect as Chatham and Barrington Islands, the highland interior through a glass presented bright patches of color with sinuous lines of vegetation, instead of the upland grassy slopes reported on the other high island. On landing we found everything in full bloom, though the flowers, as previous visitors have observed, were decidedly inconspicuous. Here and there the dreary landscape was enlivened by the sulphur-yellow flowers of *Cordia* bushes, the bloom of tall cotton bushes, and the white masses of a clematis-like *Cardiospermum* clambering over the shrubbery. Deciding on a collection of *Cordia* flowers, I spread drying papers on a little sandy spot in

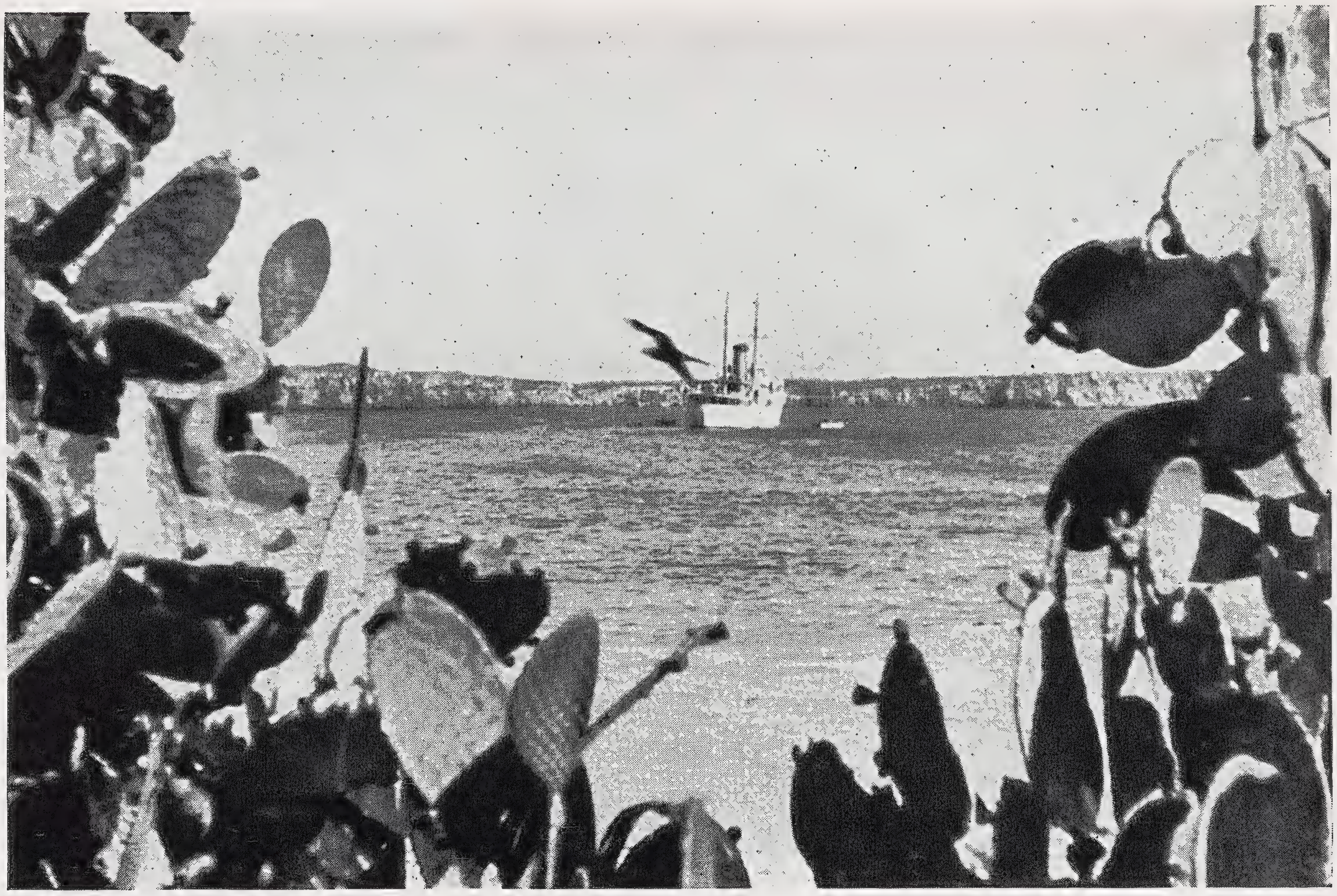
Along the Trail, Indefatigable Island.

Keeping the trail is an art.
You follow it only in part.
It doesn't look fair
In the pictures up there—
Just imagine the walk when you start.

the brilliant sunlight and soon was startled by a wonder in this region, rain. In fifteen minutes the shower was over.

About us were isolated bushes from five to fifteen feet in height; brittle branches of *Lantana peduncularis* exhaling a strong tarry smell from small white flowers and gray foliage, and the narrow-leaved form of *Croton* bush with its white bark. Upon the branches of a small *Croton* tree clung the thick green leaves and pulpy white berries of a native mistletoe, *Phoradendron henslovii,* a species later found abundantly in the moist interior. Here in the gritty brown soil were *Telanthera* bushes of at least four distinct species, and a host of small prostrate plants, insignificant in appearance but of great interest to a botanist. The abundant *Cenchrus* grass proved wholly innocuous, so different from the spiny-burred species on our Atlantic Coast. There was no shade except that cast by a large *Mancinella* tree; a beautiful tree with shiny pear-like leaves and

Cascade, Cocos Island. Photograph by C. L. Hay.

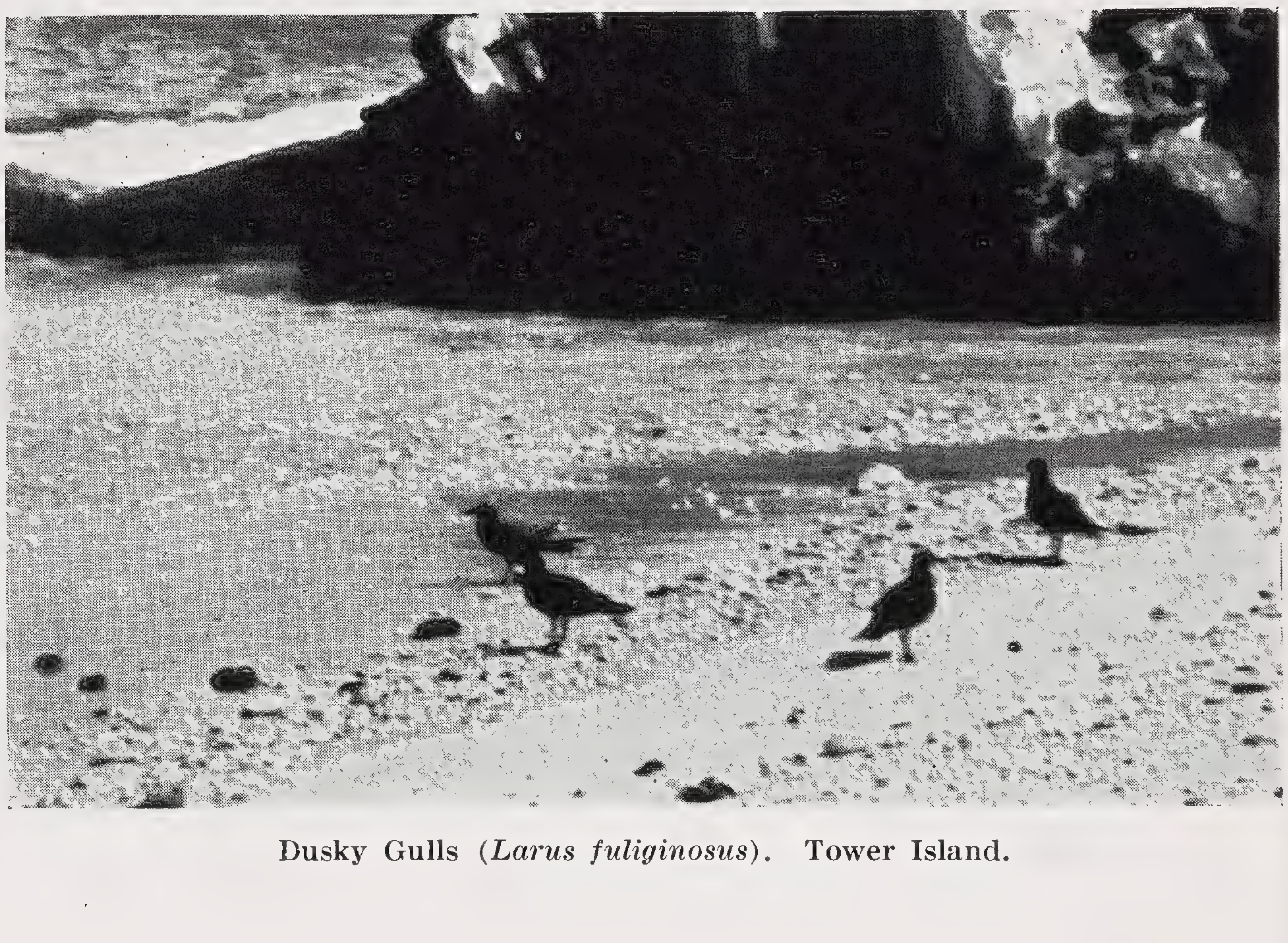


Nourmahal in Darwin Bay, Tower Island. Cactus growing around top of this crater anchorage is peculiar to Tower Island (*Opuntia helleri*).

low overhanging branches but one of the most poisonous in the tropics. The milky juice raises blisters and the attractive yellowish-green fruit, of crabapple size, makes it a dangerous object. Some of the early Spanish explorers believed that they had found apples in the New World, and ate them with fatal results. Thus arose fabulous stories as to the deadly effect of the tree upon all those who came within its shade. There seems, however, to be no question of its poisonous quality when touched. The tortoises, according to Stewart's observation, eat these fruits as well as cactus spines seemingly without any annoyance.

In general, walking was not so difficult at Academy Bay provided one kept hands and shoulders clear of *Cactus* and kept away from the hawthorn-like *Discaria* bushes. But in some places where the twisted and long-ranging *Cryptocarpus* shrubs joined in the growth and spiny *Acacia* trees were interlaced, progress under the broiling sun was nearly impossible, often with the added danger of deep crevices and tumbling fragments of lava.

Proceeding inland the ground became firmer



Dusky Gulls (*Larus fuliginosus*). Tower Island.

Fork-tailed gulls (*Creagrus furcatus*). Tower Island. Photograph by James P. Chapin.

and the direct sunlight broken by enormous cactus trees rising to thirty or forty feet; *Opuntia* with pad-like leaves and large yellow flowers, *Cereus* with candelabra trunks and small white flowers gleaming at their summits. Feathery *Bursera* trees were intermingled, and in hollows appeared the shrubbery *Clerodendron molle,* closely simulating our swamp azalea (*A. viscosa*) both in habit and flower. A coarse grass (*Setaria*) covered the ground and along the pathway were both yellow and pink-flowered leguminous vines, and the new species of *Cissampelos* (*C. galapagensis*) found by Stewart in 1905 and so far as known restricted to Academy Bay. A seventy-five foot escarpment a half-mile inland gave a delightful view through *Bursera* trees to the blue waters of Academy Bay and the roofs of our encampment. Its lava-block slope was covered with yellow flowers of wild tomato, purple passion-flowers, and in crevices grew the strange fern, *Trachypteris pinnata,* with broad untoothed basal leaves and ordinary fern leaves above, an adaptation well suited to withstand the dry weather.

A gradual ascent of 200 feet brought the

Booby (*Sula*) Tower Island.

Man-o-War birds greeting the Nourmahal. Tower Island.

cactus to an end, its place taken by a luxuriant and beautiful growth of leafy trees (*Psidium, Pisonia,* and the queer tree-composite, *Scalesia*). Grass gave way to a dense tangle of vines climbing among the fragrant heliotrope bushes and ascending the trees, and to mats of a small blue-flowered *Commelina* and a reddish *Justicea.* Upon tree trunks perched ferns and fleshy *Peperomias,* with hanging white and purple flowered clusters of the splendid little orchid, *Ionopsis,* and dangling festoons of absorbing roots of Pareira vine (*Cissampelos pareira*).

Suddenly at 700 feet we came upon a partly abandoned plantation, with rich black soil of great depth, extremely fertile, with groves of banana trees obscuring the sunlight, and a great area of squashes, elephant ears (*Colocasia*), sugarcane and coffee. The second growth about this plantation was murderous to get through, consisting of closely interwoven *Psychotria* bushes, prickly-ash trees (*Zanthoxylum*), bush nettles (*Urera*), and tall ferns. The real ascent soon began. Damp rocks and overhanging cliffs were carpeted with numerous species of ferns (maidenhair, spleenworts, and filmy ferns) and a round-leaved chickweed (*Drymaria*), and three species of orchids were found all past flowering. At 1500 feet appeared the first *Miconia* shrubs, resembling lilacs in growth, with handsome foliage and masses of purplish flowers and a prodigious growth of stems. Hacking through an interminable thicket of these shrubs we reached above 2000 feet, where occasional glimpses into slightly open country showed *Miconia* dominating the whole upland southern slope of Indefatigable Island. Preliminary study places this shrub as *Miconia robinsoniana,* known very sparingly on the upper regions of Chatham Island, and its dominance links the vegetation of the Galapagos a

A tide pool view. Tower Island.

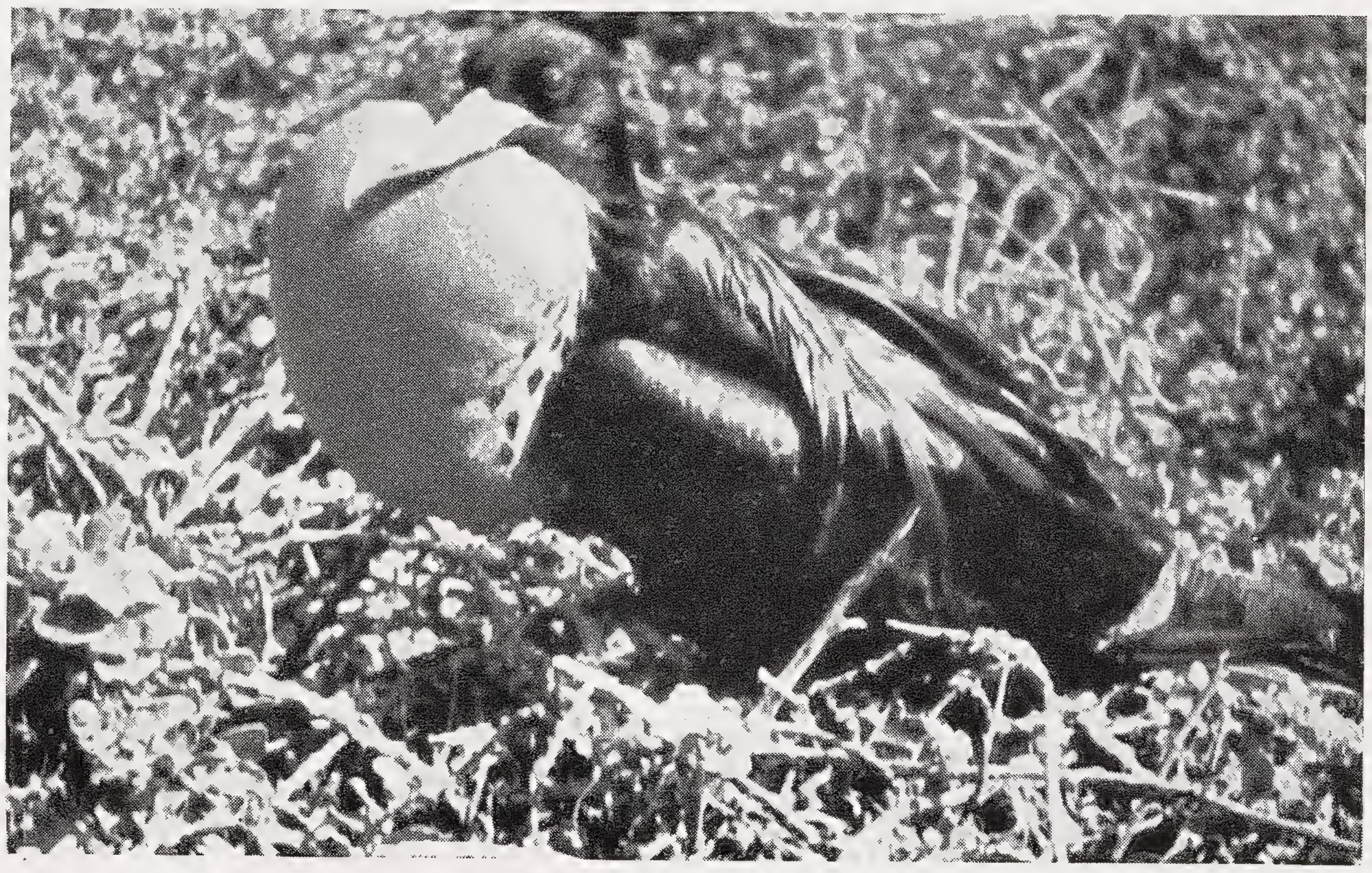
The conspicuous red and yellow crab. Abundant on the rocks.

little closer to that of Cocos Island where *Miconia*-like shrubs are abundant. The undulating lines seen toward the summit on our approach to the island probably represent spaces filled with tall brake-ferns and occasional prickly-ash trees enveloped in a brownish moss, and teeming with epiphytic ferns and club-mosses. Here and there the soggy ground was covered with ferns or *Lycopodium clavatum,* a common club-moss of the eastern United States, or in a few sunlit places by small patches of a sedge (*Scleria*). Glimpses through the fog banks which almost continually settle down on this region seem to show the same general type of vegetation extending through the table land which forms the summit of Indefatigable.

A visit to the tortoise country where several small ponds were reported by Mr. Astor's exploring party did not turn out to be as fruitful as had been anticipated. The grasses through which the tortoises wallowed and the aquatic plants duckweed (*Lemna*) and water-ferns (*Azolla*), were all common plants widely diffused through the tropics. About these mosquito-infested pools were masses of *Clerodendron* bushes and *Mancinella* trees, and the grassy openings were surrounded with small prickly-ash and *Acacia* trees, and large cotton bushes. Clumps of yellow *Cassia* flowers now and then gave color to the desolate scene.

The exotic vegetation of the island consists largely of weeds brought in by tortoise hunters and colonists, and cultivated plants such as papayas, castor-oil bushes, squashes, etc., some of which will undoubtedly persist long after complete abandonment of the plantations. From my brief experience the vegetation of the coastal regions appears the most varied and interesting, and there is a startling difference between the similarly dry coasts of Academy Bay, Charles Island, and the north shore of Indefatigable.

One of the most noteworthy finds was the discovery by Dr. Pool of the soft-leaved *Bursera* (*B. malacophylla*) on Daphne Island, previously known only from a single collection made by Snodgrass and Heller on Seymour Island in 1899. A preliminary survey of the plants collected on Indefatigable Island shows that very few, if any, are actually new to sci-



Man-o-War Bird (*Fregata aquila*). With red throat sac inflated. Tower Island.

ence, but that at least forty of the species have never previously been found on the island. Investigation of the jagged rocks which can be seen with a glass at the north edge of the tableland and of the isolated peaks in the center may perhaps yield something more.

Man-o-War birds nesting. Tower Island.

Growth and Age of Giant Tortoise

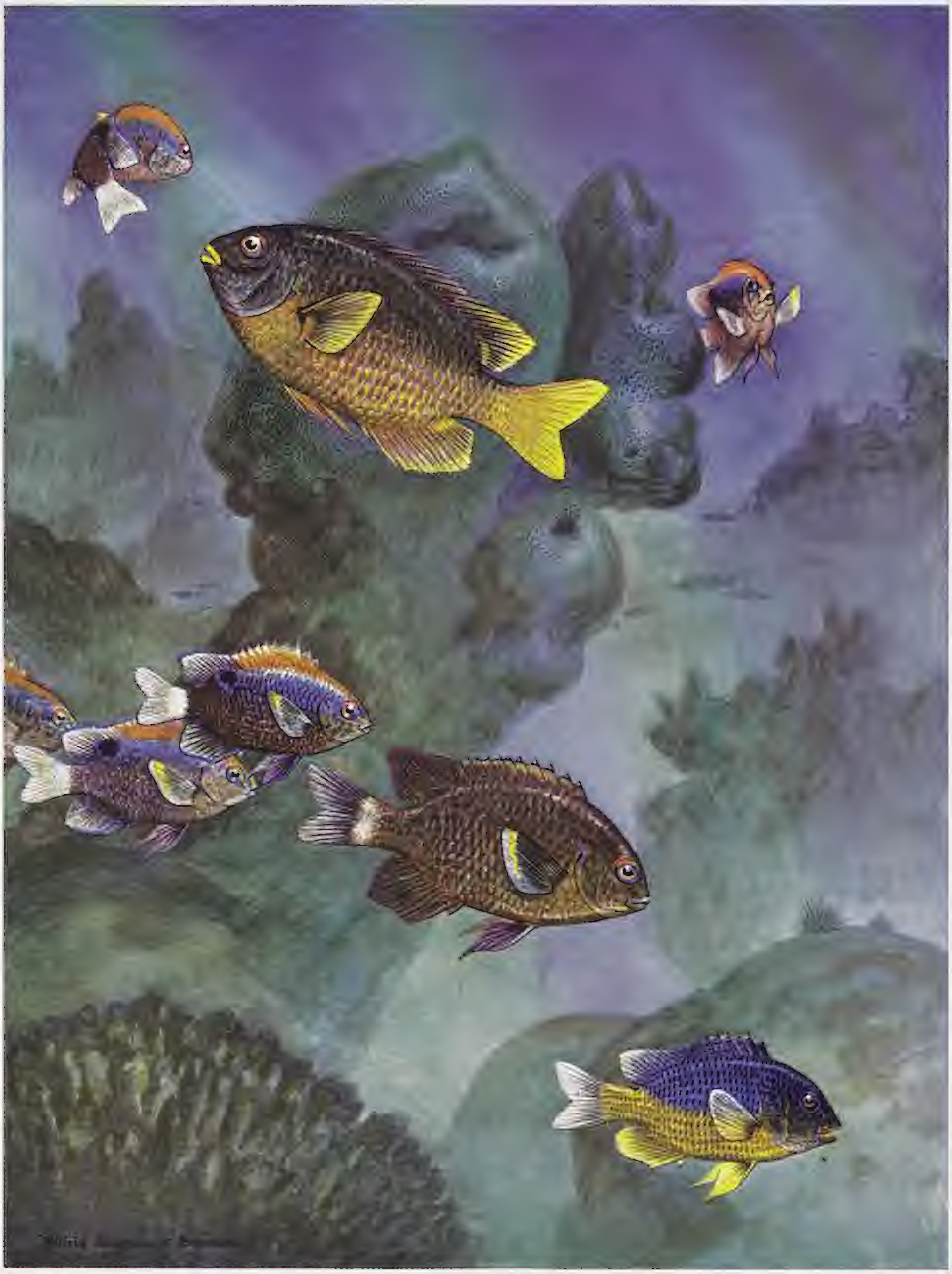
A question frequently asked relates to the *age* attained by the giant tortoise. Little is known of the age of animals except in cases observed under conditions involving long continued captivity. There are three or four apparently authentic records of giant tortoise that were kept in semi-domestication for periods exceeding 140 years, when they died soon after being removed to cold climates.

More is known of tortoise *growth* in captivity. A twenty-nine pound Galapagos tortoise taken to California by Mr. Edmund Heller, attained a weight of 415 pounds in fifteen years. The younger Galapagos tortoises in the colonies established along the southern border of the United States by the New York Zoological Society, have in general doubled in weight each year since 1928. The older specimens have grown less rapidly.

The following record from Houston, Texas, showing growth for two years, may be taken as typical:

Tag Numbers	Weight Lbs. June 18, 1928	Weight Lbs. July 11, 1930
90	13¾	44
91	10	39
92	7	35
93	8	45
94	7⅞	39
95	10	40
96	12	61
98	7¾	47
99	10	46
100	9	47
101	8	32
102	8	28
103	10¼	40
104	71	166
	Total Lbs. 192	*Total Lbs.* 709

Booby (*Sula*). Tower Island.



Galapagos Fishes of the Genus *Pomacentrus*. Largest—above—from Seymour Island. At bottom, from Tower Island. Others from Tagus Cove, Albemarle Island. Many specimens of these fishes were brought alive to the New York Aquarium by the Astor Expedition. The preserved material has not yet been studied.
Painted from life by Wilfred S. Bronson.

Dr. Pool is charmed with the penguins.

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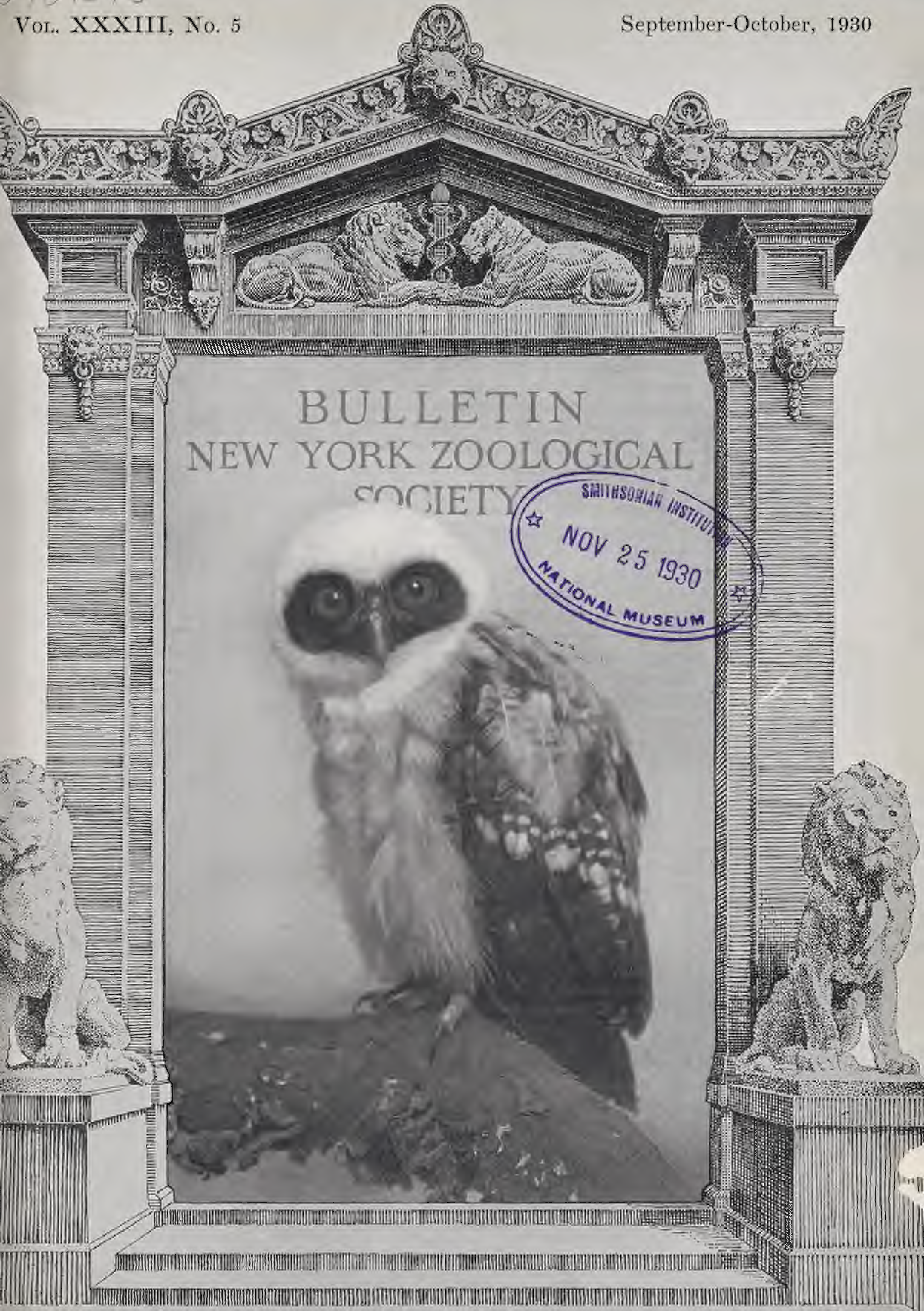

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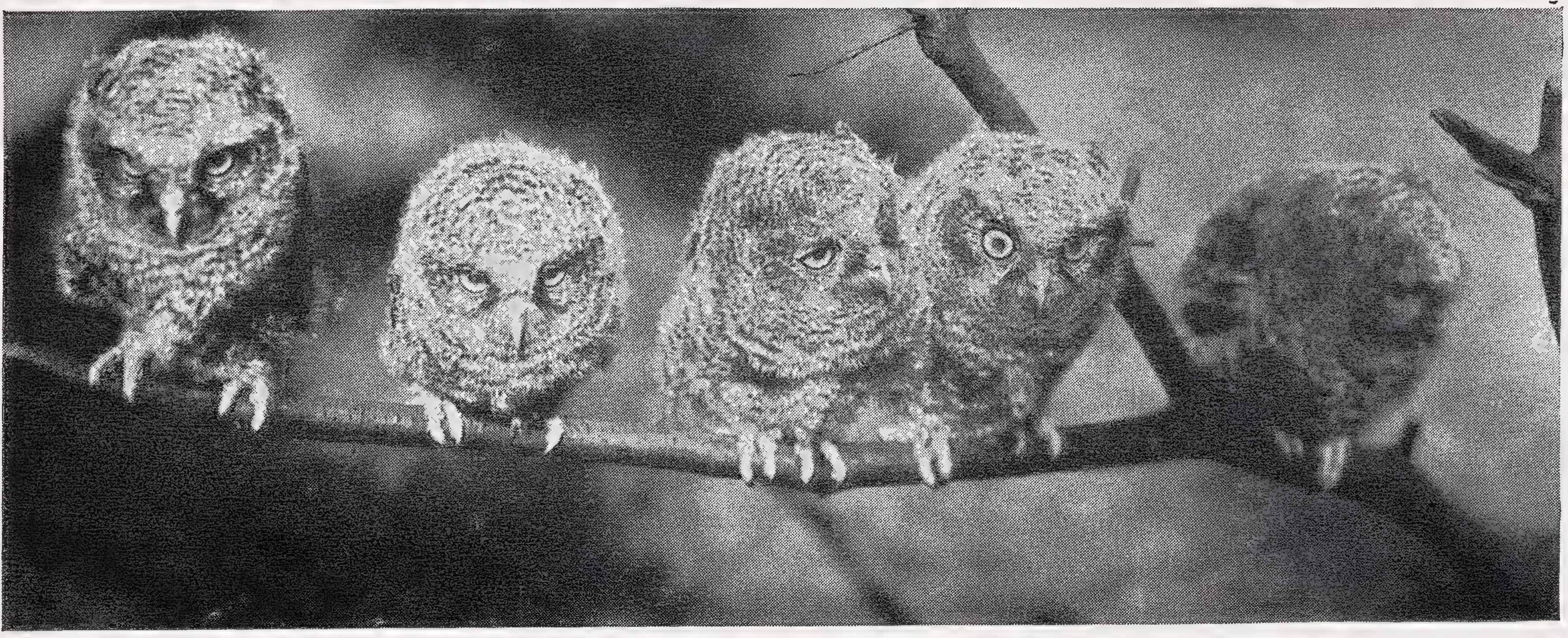

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BULLETIN

New York Zoological Society

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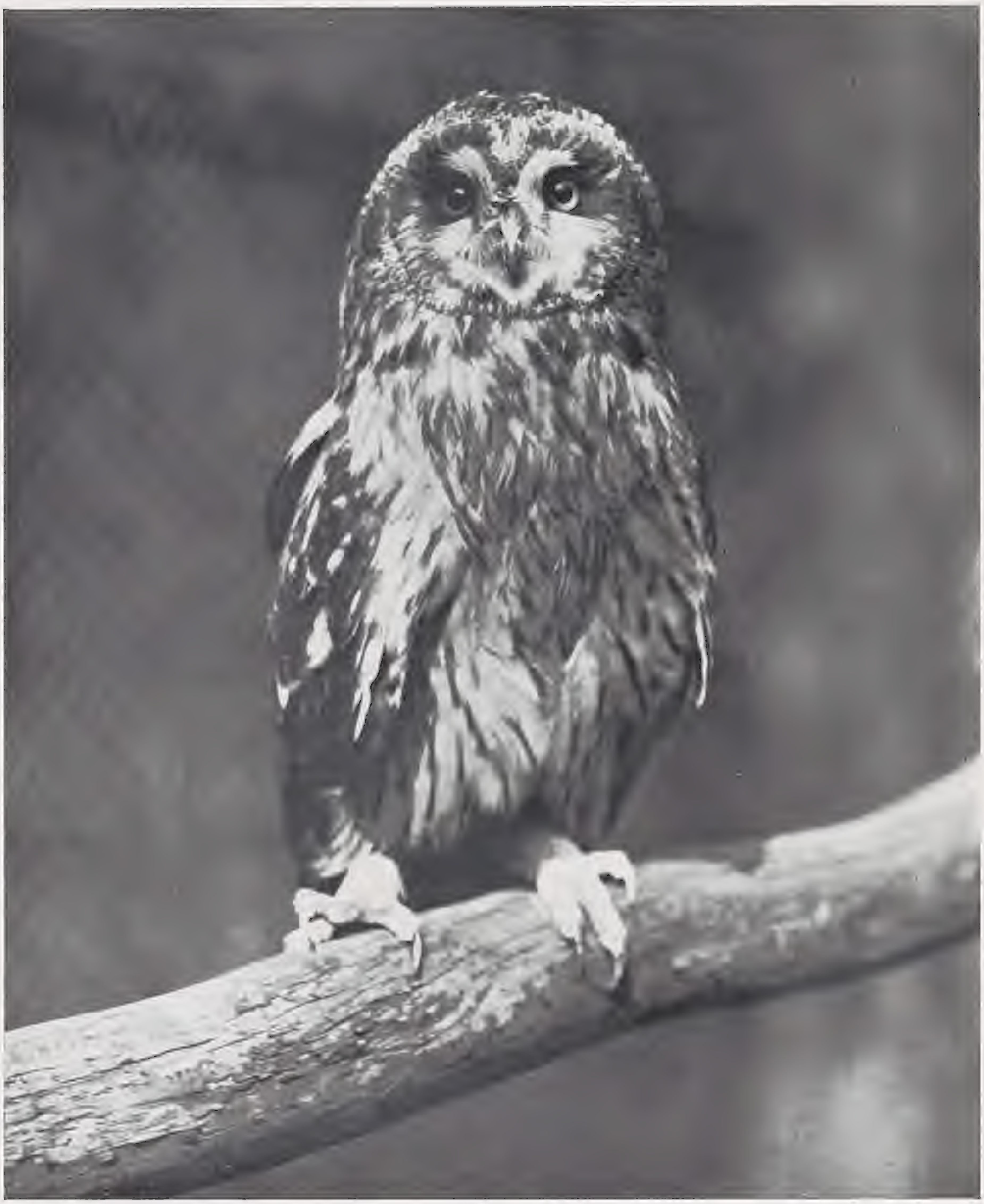
Editorial and Subscription Offices, Zoological Park, New York City, Elwin R. Sanborn, Editor.



Short-eared Owl. *Asio flammeus flammeus* (Pont.). A species of wide distribution, found in many parts of the world. The following story, in which the bird figured played a leading part, was furnished by First Assistant Engineer Harris, of the steamer *Western Ocean*: "When the S.S. *Western Ocean* was, on October 3, 1930, at Latitude 23° 2′ N. Longitude 66° 53′ W. an owl was sighted close to the ship. We were about 800 miles north-east of Porto Rico at the time, and the only way in which we could account for the presence of the bird in that location was a small storm center that had passed there the day before and carried the bird from shore. The Chief Engineer kept watch for the bird for a day and a half, and during that time he would only come on board for short periods of rest. He could not seem to keep going with these short snatches of rest, and by noon of the second day decided to make himself at home on one of the ventilators leading to the fire-room. The fireman on watch at the time heard a peculiar screeching noise and after vainly trying to locate it in the fire-room and meeting nothing but failure, decided to report it to some one with more authority than he had. After being notified, the Chief Engineer, hearing the noise and being a hunter of sorts, recognized the call of the owl and decided to catch it. Guns or poison being out of the question, a few yards of mosquito netting were used and after maneuvering behind the bird, it was successfully caught.

BULLETIN
NEW YORK ZOOLOGICAL SOCIETY

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The Owls

Lee S. Crandall

Illustrations from photographs in the collections of the New York Zoological Society, made by Edward R. Osterndorff, except as noted under the cuts.

By the ancients, owls were regarded with superstitious dread. This feeling still persists among most savage peoples and also, unfortunately, in many countries where modern enlightenment should long ago have suppressed it. This sense of fear and awe is derived, no doubt, from the apparently mysterious ways of owls—their nocturnal habits, their silent flight, their weird voices and their staring eyes. Some, as the barn owls, even add a strikingly human facial expression to their other qualifications as ogres. In reality, they are the most beneficial of gnomes, for their never-ending war on rats and mice renders us a priceless service.

Owls make their homes in almost every part of the earth, from the polar regions to remote tropical islands. While the characters of owls separate them so distinctly from other birds that they are recognized at sight by almost everyone, there is much specific variation within the group, and well over four hundred forms have been described.

Competition for food amongst the various groups of birds is very keen, and most of the owls have become adapted for hunting at night. A few, such as the snowy owl, the hawk owl and the burrowing owls, are diurnal, and the barred owls are partly so. But the majority spend the bright hours of daylight dozing in hollow trees or in dense cover, and become active only at the approach of dusk. This is the time when many small creatures on which owls feed begin to move about, and owls have many specializations to aid in capturing them.

The eyes are proportionately large and the pupils capable of being greatly distended, so that advantage may be taken of even the faintest glimmer of light. Moreover, the eyes are so placed that they are capable of a greater degree of convergence than is to be found amongst any other birds. The general belief that owls are quite blind in daylight is, of course, quite untrue, for the birds are able to see perfectly well. I once saw a captive barred owl, on a bright, sunny day, gazing intently at the bottom of its cage, ten feet below. I examined the floor carefully to find the object of his attention, but for some time I could detect nothing. Eventually, I found that he was watching an unfortunate earthworm, which was wriggling in a concrete pool, beneath more than a foot of water.

Many species, such as the eagle owls, horned owls and screech owls, wear two long tufts of feathers or "ears" on the head. These appendages appear to have no connection with the sense of hearing since others, as the barn owls and barred owls, are equally sensitive to sound. In the stillness of dusk in marsh and woodland, the faintest squeak of the tiniest mouse is instantly detected. For the real ears, hidden beneath the plumage of the head, are large and well developed. In the barn owls, the ear openings are very large and provided with a fleshy flap. The long-eared and short-eared owls have the advantage of ears that open in opposite directions—one upward and the other downward. In the little saw-whet and its relatives, this specialization of the ear has been carried so far that the shape of several bones of the skull has been modified.

The silent flight of the owls is made possible by the fact that the feathers of the wings—and of the entire body, for that matter—are provided with soft, velvety surfaces, which act as mufflers. This provision, of course, is of the greatest advantage for the stealthy movements which are necessary if the owl is to have good hunting.

In most owls, the color of the plumage is a neutral gray or brown, so streaked and mottled that the bird, in its natural surroundings, is very difficult to observe. During the daytime, the truly nocturnal species try earnestly to efface themselves, and whether or not the obliterative plumage is regarded as a direct adaptation to this purpose, it certainly is an effective means of protection. Any one who has seen a screech owl with his body drawn erect, his feathers compressed to the smallest possible circumference, his raised ears extended to fine points, and his eyelids closed to mere slits, will understand how a small bird, hunting a thicket for insects, might overlook his enemy of the evening. This daylight precaution on the part of the owl is largely due to his dread of discovery by his small victims. Once a sparrow or a warbler has sighted an owl during the daytime, the role of hunter and quarry is reversed. In response to the alarm notes of the spy, the bird population of the neighborhood is immediately aroused to hysteria, and such a din of shrieks and cries is raised, that more powerful enemies are likely to be attracted to the scene.

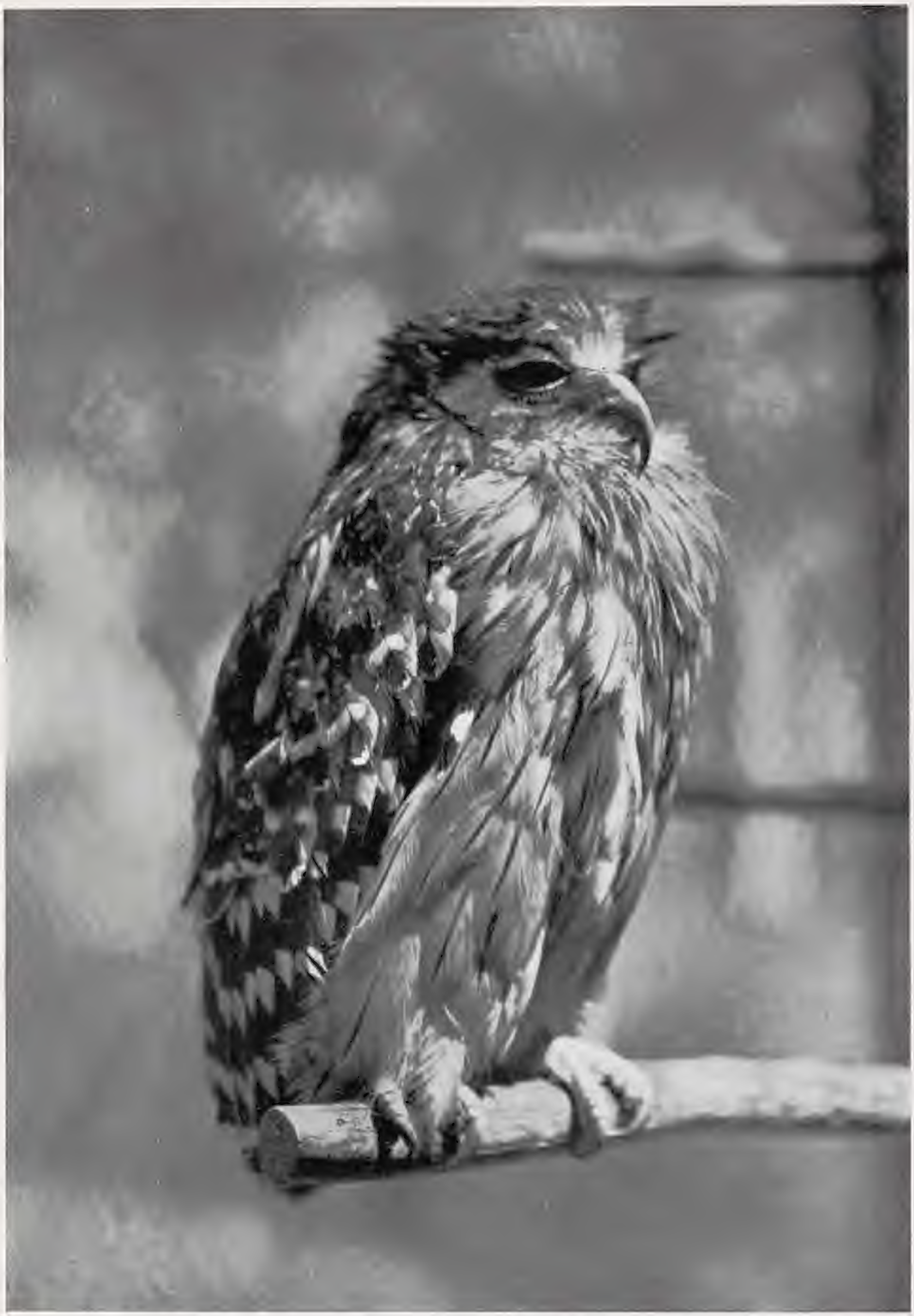
The food of owls consists principally of small mammals, birds, frogs, fishes and insects, each species having its own special preferences. The barn owl, for instance, feeds principally on mice, eked out with insects and occasional small birds. The great horned or eagle owls, strongest and fiercest of the tribe, may kill animals as large as lambs and birds to the size of turkeys. During the winter months, horned owls sometimes make their homes in the Zoological Park and make havoc among our out of door collections until they can be suppressed. Early in 1919, our water fowl suffered severely from the attacks of a mysterious marauder, many ducks and geese, and even a black swan, being numbered among the victims. Their outraged keeper spent several nights on guard but never could find the culprit. At length, as he was passing the Pheasant Aviary on his rounds, he saw a pair of great, luminous eyes blazing at him from the top of the trellis work. He could see nothing else, but he fired at the point where he judged the body of the owner of the eyes should be and down came a tremendous owl. It later proved to be an artic horned owl, a member of a very pale race from the far north, and the first record of its occurrence in New York State. Its remains now repose in the American Museum of Natural History.

The fishing owls of Asia and Africa feed largely on fishes. In them, the lower legs or tarsi, are bare of feathers and the toes are armed with small spikes or "spiculae," useful features for a fisherman.

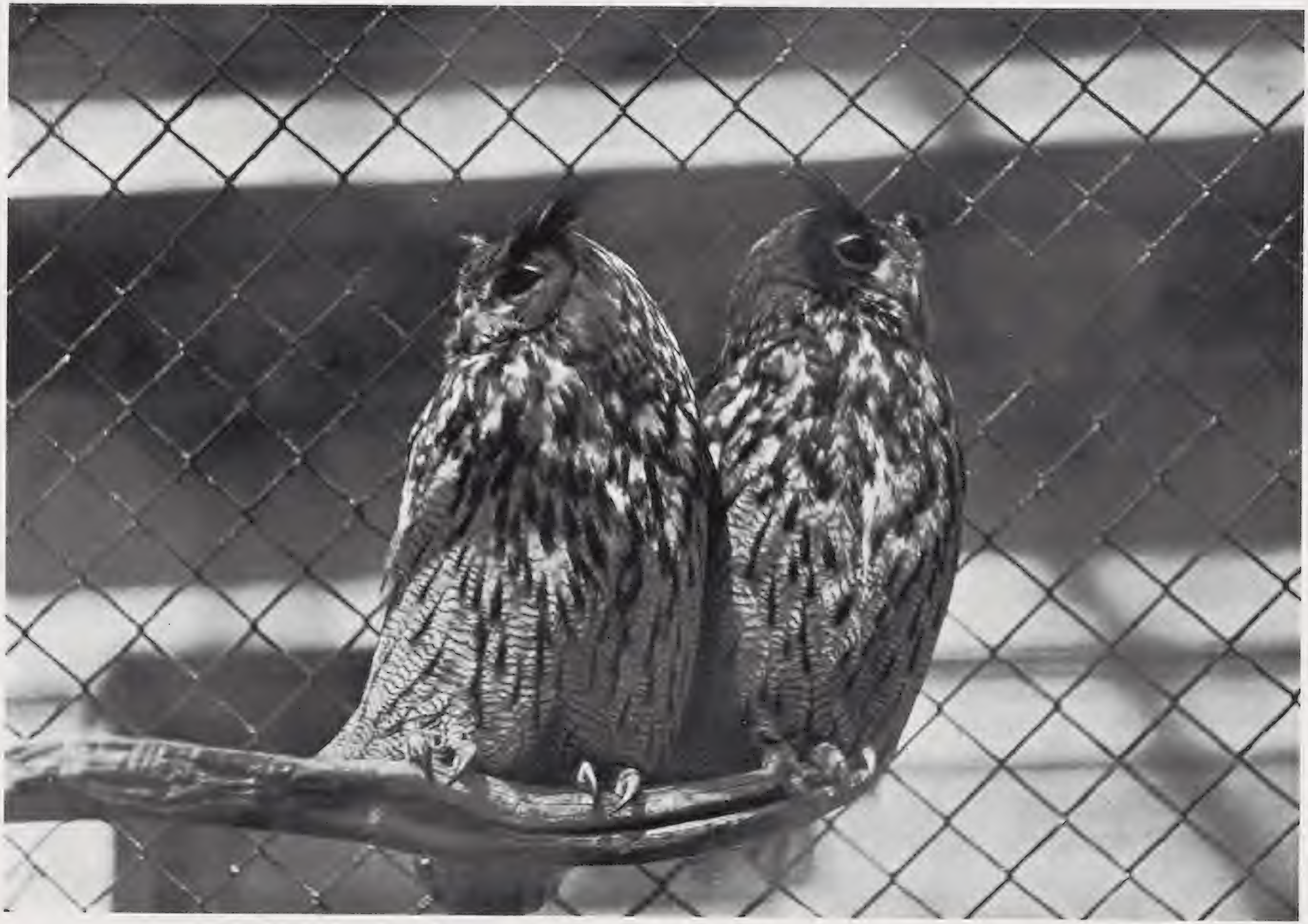
The voice of owls vary from the loud *"Hoo-hoo-hoo"* of the horned owls to the weird yells and screams of the barred owls. The barn owl, in addition to its louder calls, utters, in moments of alarm, a loud, wheezing hiss.

On one occasion, three young barn owls, about half grown, were brought to the Zoological Park. Because feeding at frequent intervals was necessary, the young owls were placed in a large covered basket, which was kept in the keepers' room at the Large Bird House. That night, a Negro watchman, entering the rooms on his rounds, was greeted by a terrifying *"whoosh!"* from the startled owls. To this day, the watchman declares the Bird House to be inhabited by "ha'nts" and always enters it by a circuitous route, which does not include the keepers' room. Many tales of haunted buildings must have started in a similar manner.

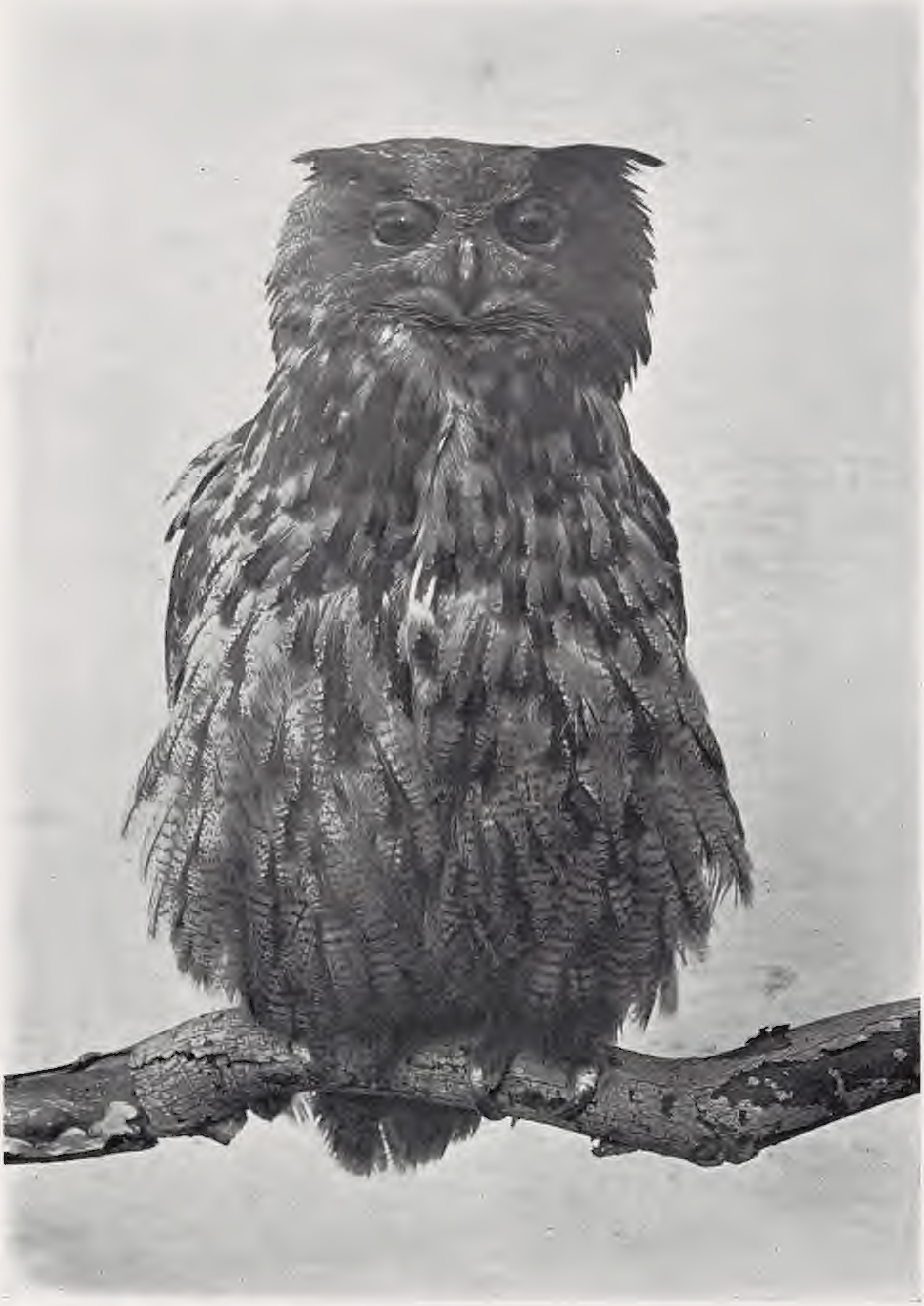
While owls are shy and secretive birds, their nocturnal habits give them a great advantage in resisting the encroachment of man on their domains. In the outskirts of New York City, the screech owl still persists as a breeding bird. On May 27, 1930, a brood of newly hatched barn owls was discovered in an empty water tank on the roof of a foundry at 138th Street and East River, New York. Hardly a winter passes in which the Zoological Park is not visited by barred or great horned owls, usually with resultant loss to us. Long after the hawks have succumbed to the constant persecution that besets them, the owls will continue to thrive.



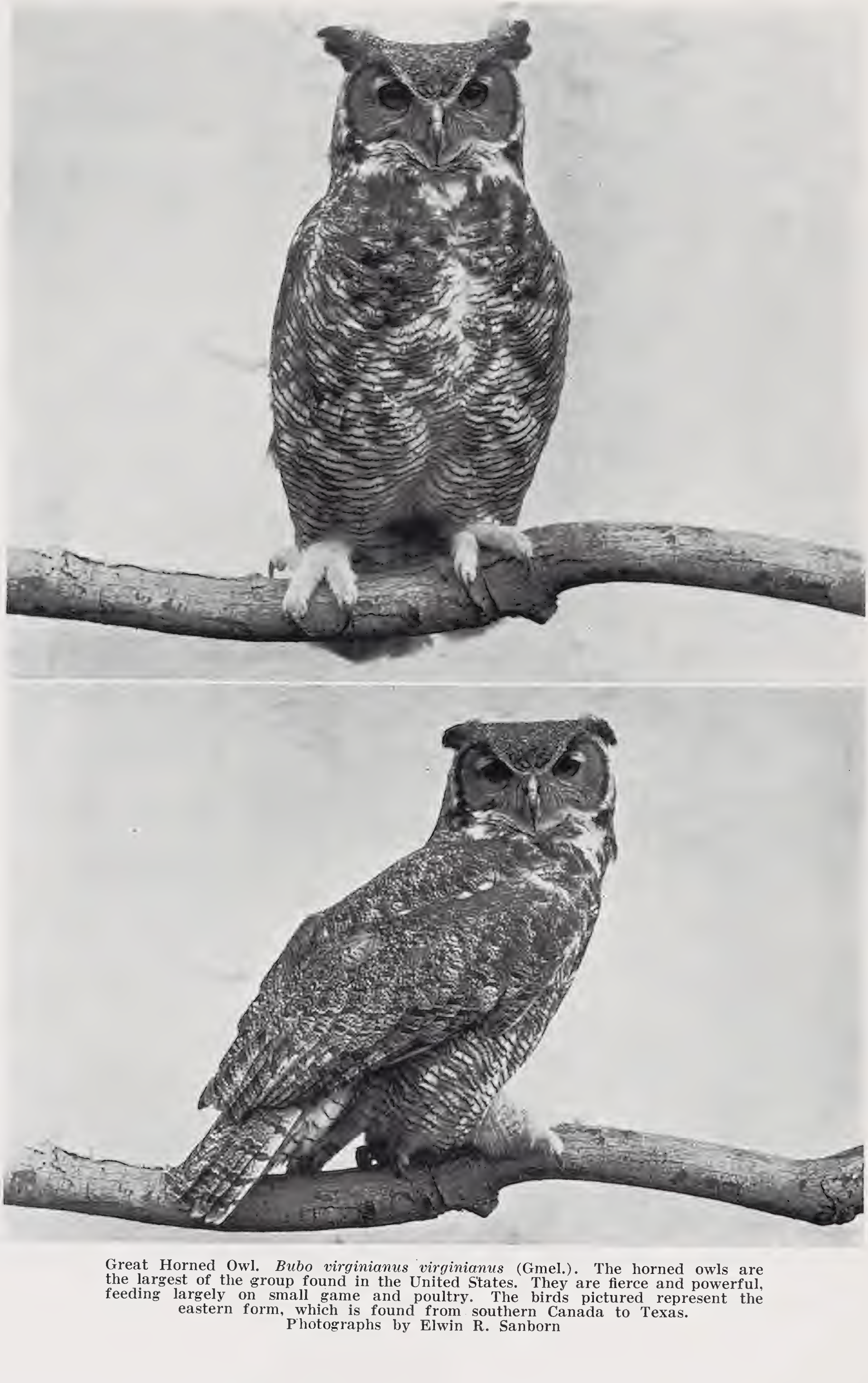
Javan Fishing Owl. *Ketupa ketupa* (Horsf.). As their name implies, the fishing owls feed largely on aquatic creatures, including fish, frogs and crustaceans. They do not, however, disdain either birds or mammals, when these are easily obtainable. This species is found from Cochin China and the Malay Peninsula to Java and Borneo.



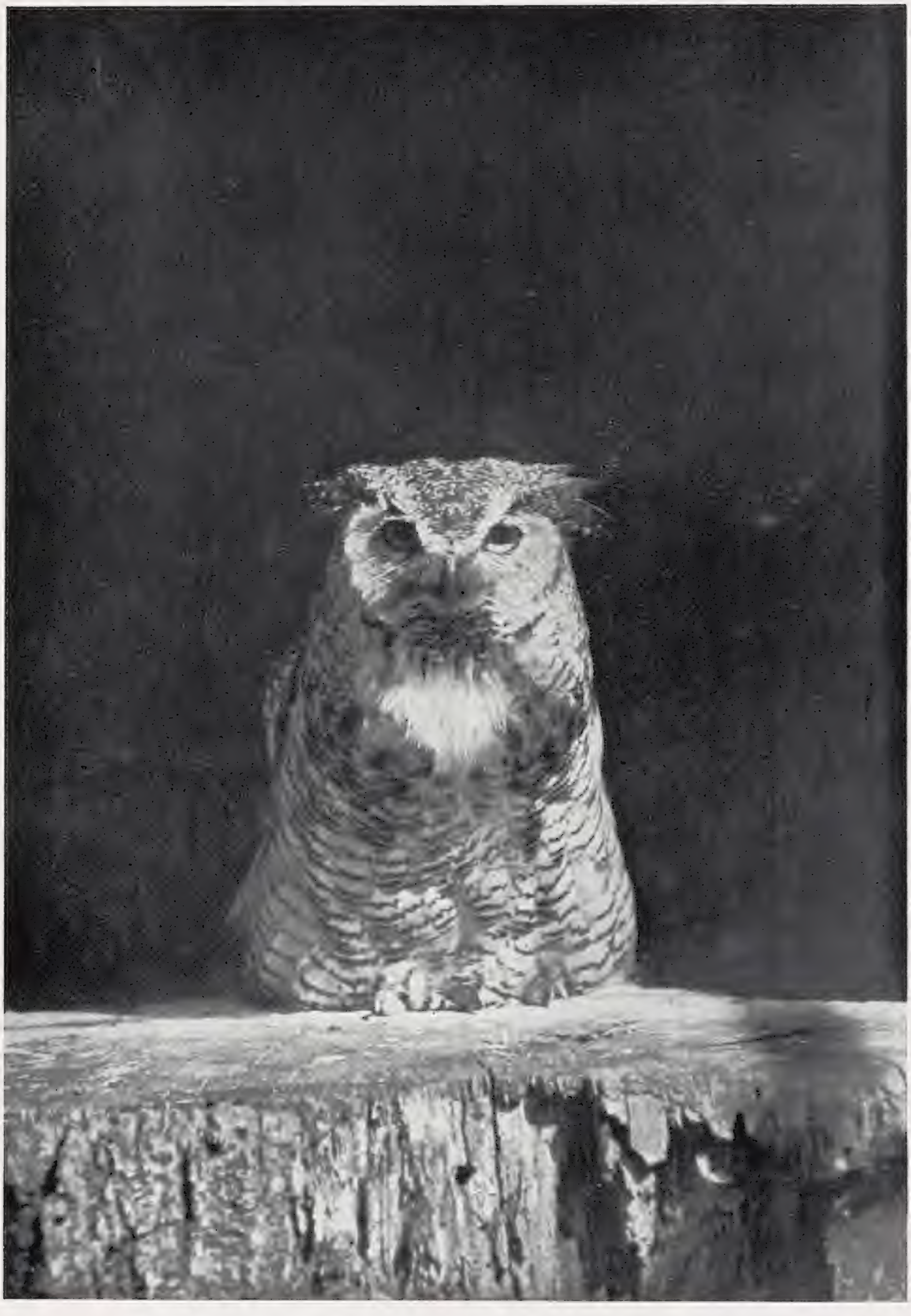
Giant Eagle Owl. *Bubo bubo bubo* (Linn.). Rare in the British Isles, this large and ferocious owl is still found on the continent, from Scandinavia and northern Russia to the Mediterranean countries. Because of its great size and power, it is very destructive to game, as well as to poultry and the smaller domestic animals.



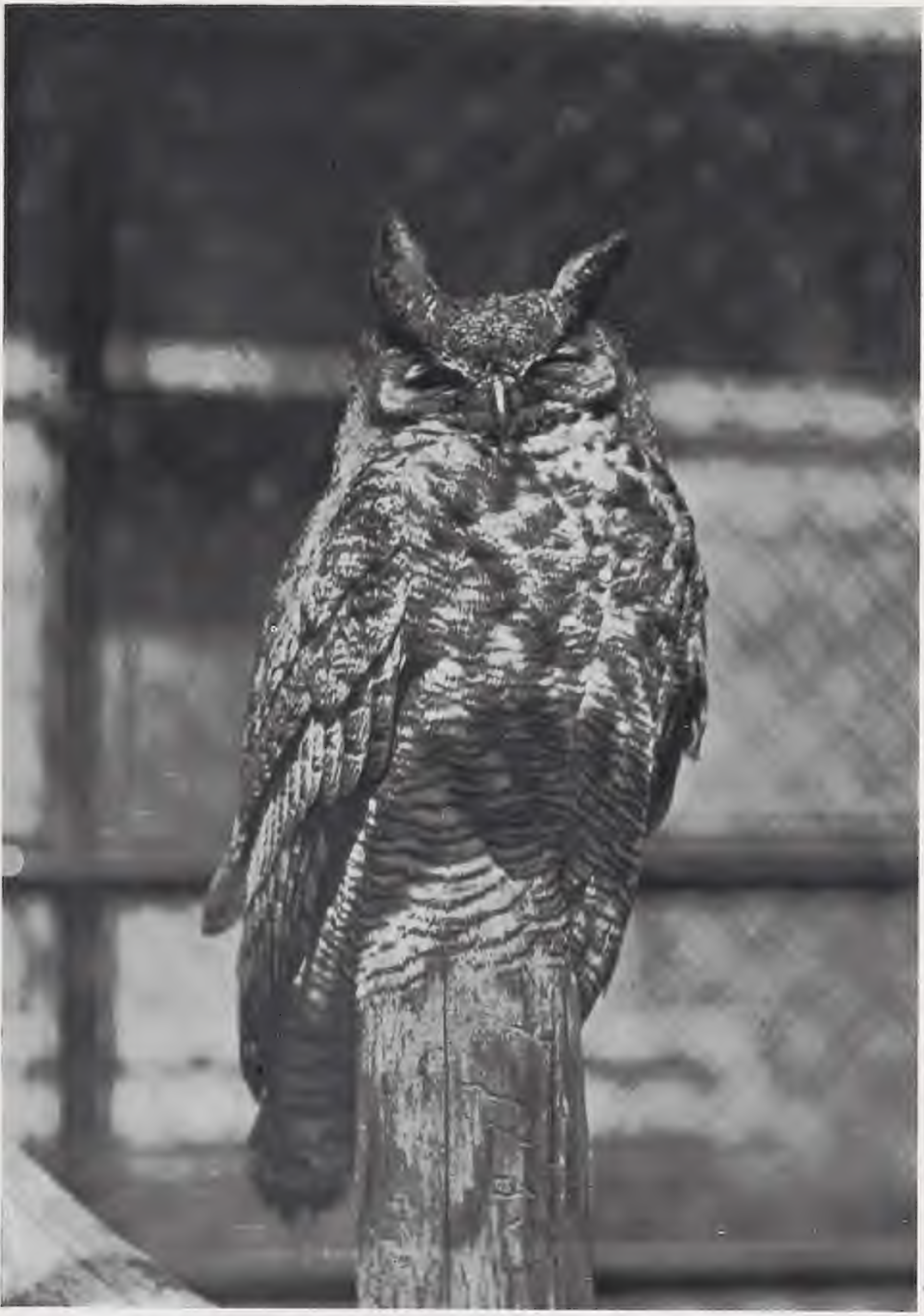
Giant Eagle Owl. *Bubo bubo bubo* (Linn.). Beside the typical form, found only in Europe, six other subspecies are recognized, extending from Spain to China. Of these, only the very pale Siberian Eagle Owl (*Bubo bubo sibiricus*) has been represented in the collections of the Zoological Society.
Photograph by Elwin R. Sanborn



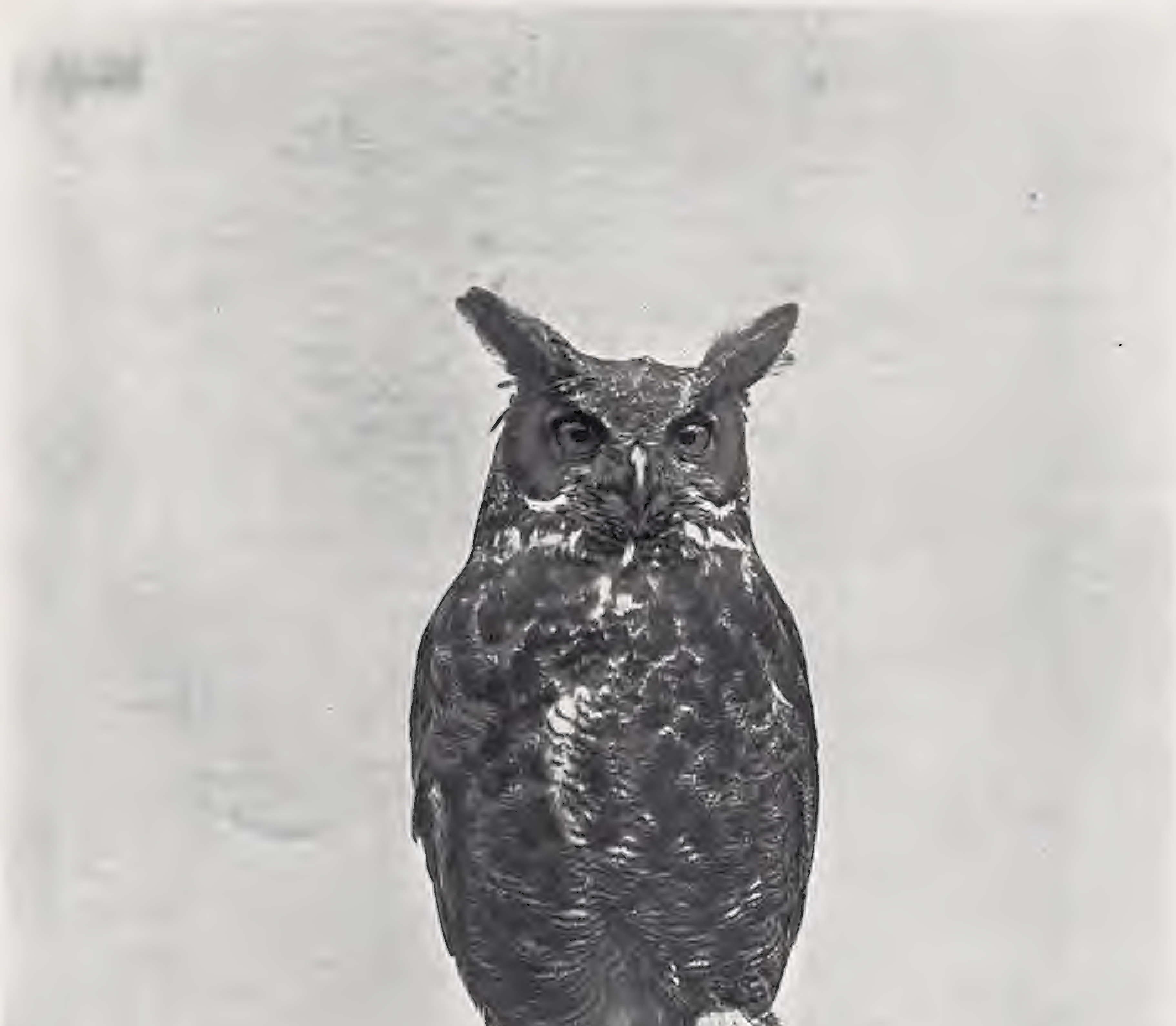
Great Horned Owl. *Bubo virginianus virginianus* (Gmel.). The horned owls are the largest of the group found in the United States. They are fierce and powerful, feeding largely on small game and poultry. The birds pictured represent the eastern form, which is found from southern Canada to Texas.
Photographs by Elwin R. Sanborn



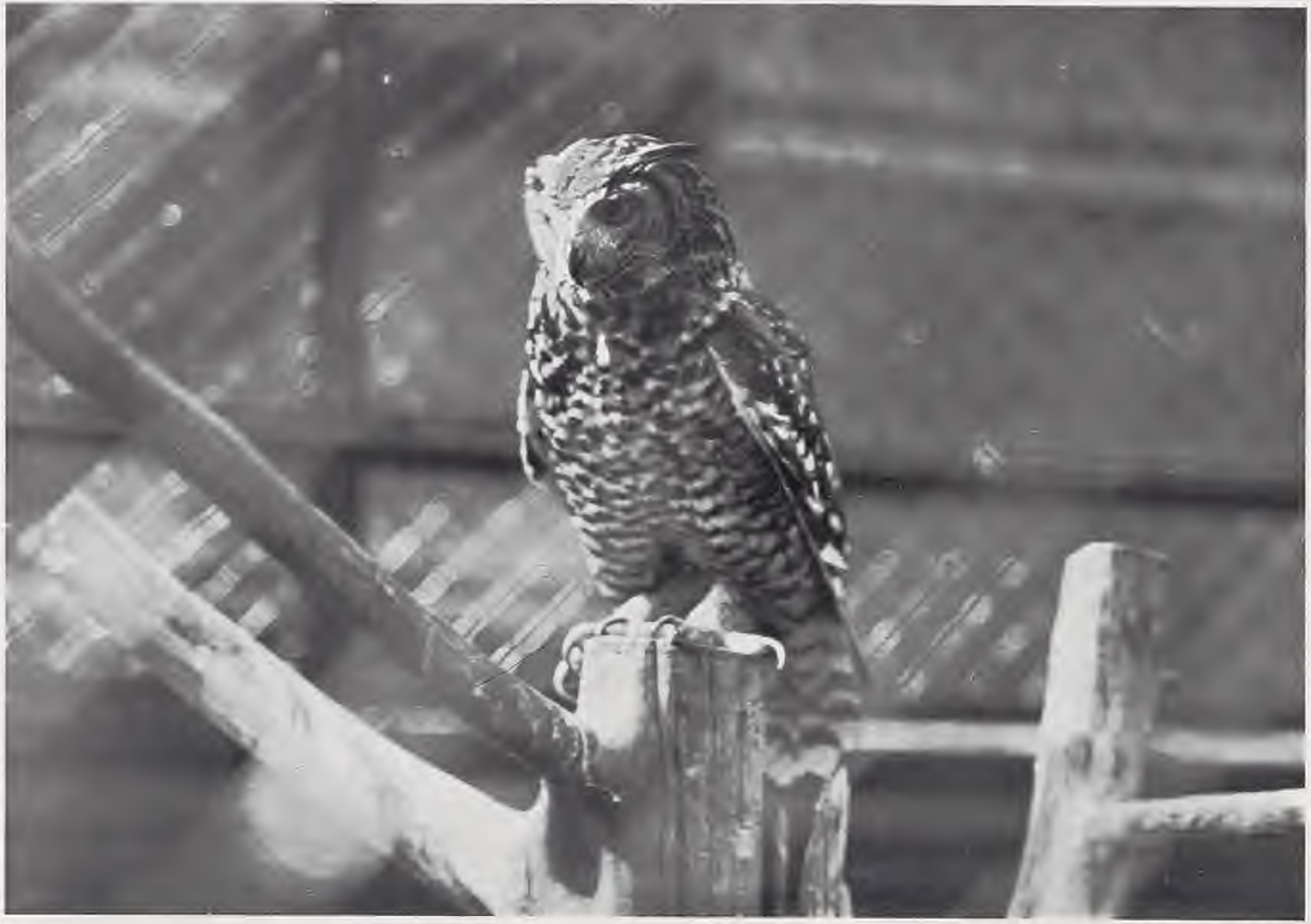
Arctic Horned Owl. *Bubo virginianus wapacuthu* (Gmel.). About twenty forms of *Bubo virginianus* are recognized, ranging from the Arctic Region to Patagonia. In this subspecies, which breeds from northern Canada to Manitoba, the ground color of the plumage is white.



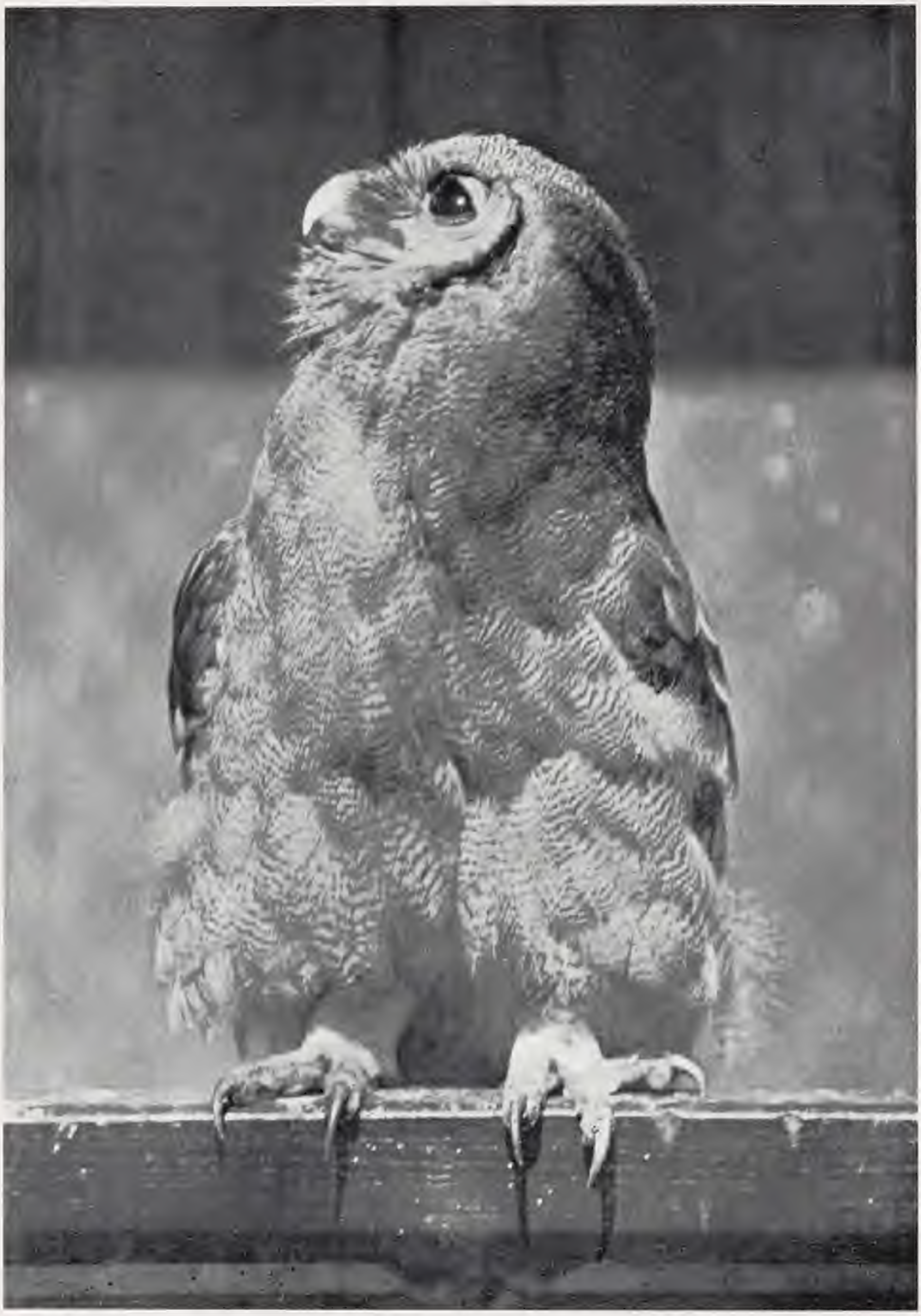
Pacific Horned Owl. *Bubo virginianus pacificus* Cassin. This western representative of the horned owls is smaller and darker than the eastern bird. It is found from southern Oregon to central Arizona.



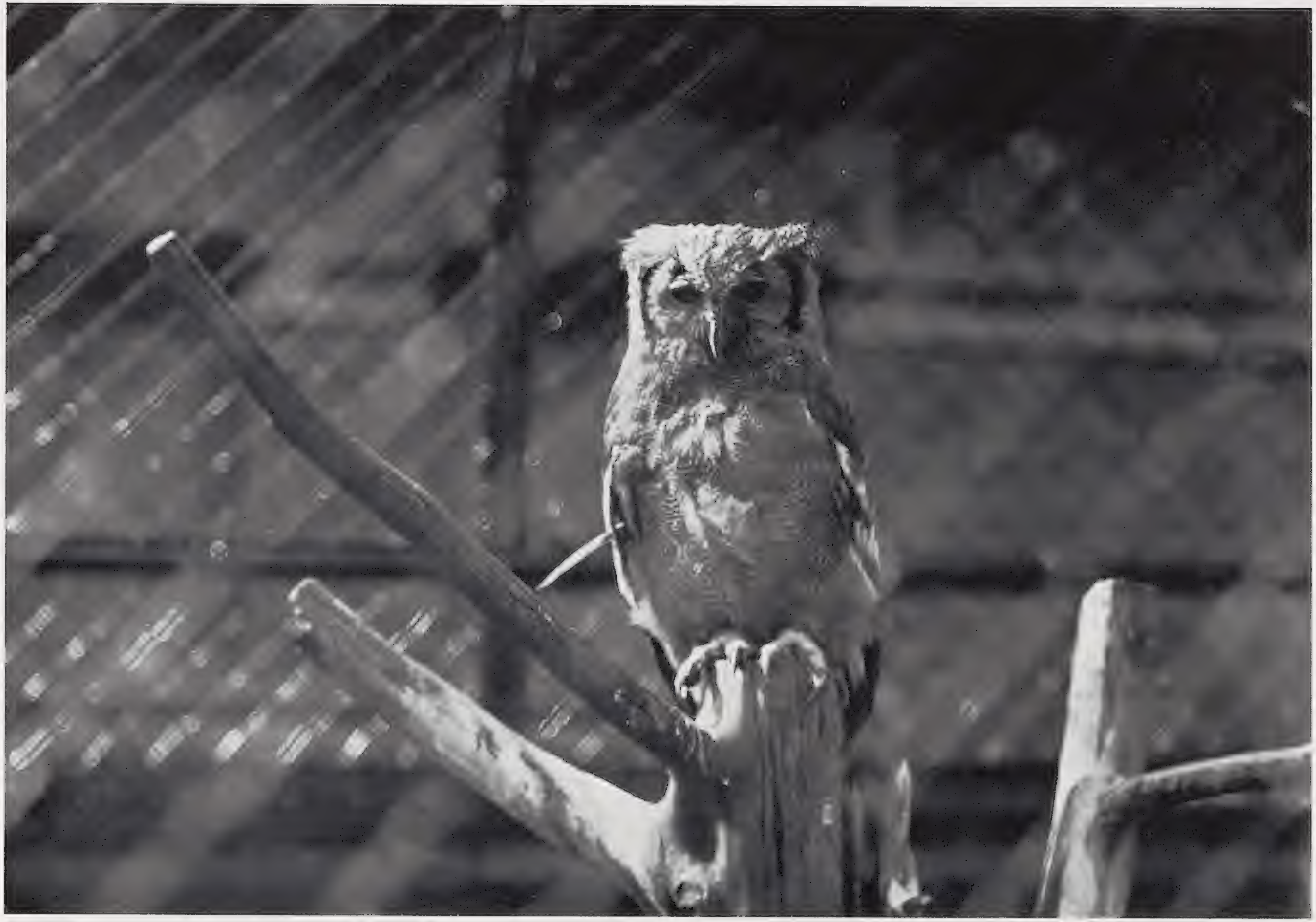
Dusky Horned Owl. *Bubo virginianus saturatus* Ridgway. Both the common and technical names of this bird suit it well, for in color it is the darkest of all the horned owls. It inhabits the Pacific coast, from northern California to Alaska. Photograph by Elwin R. Sanborn



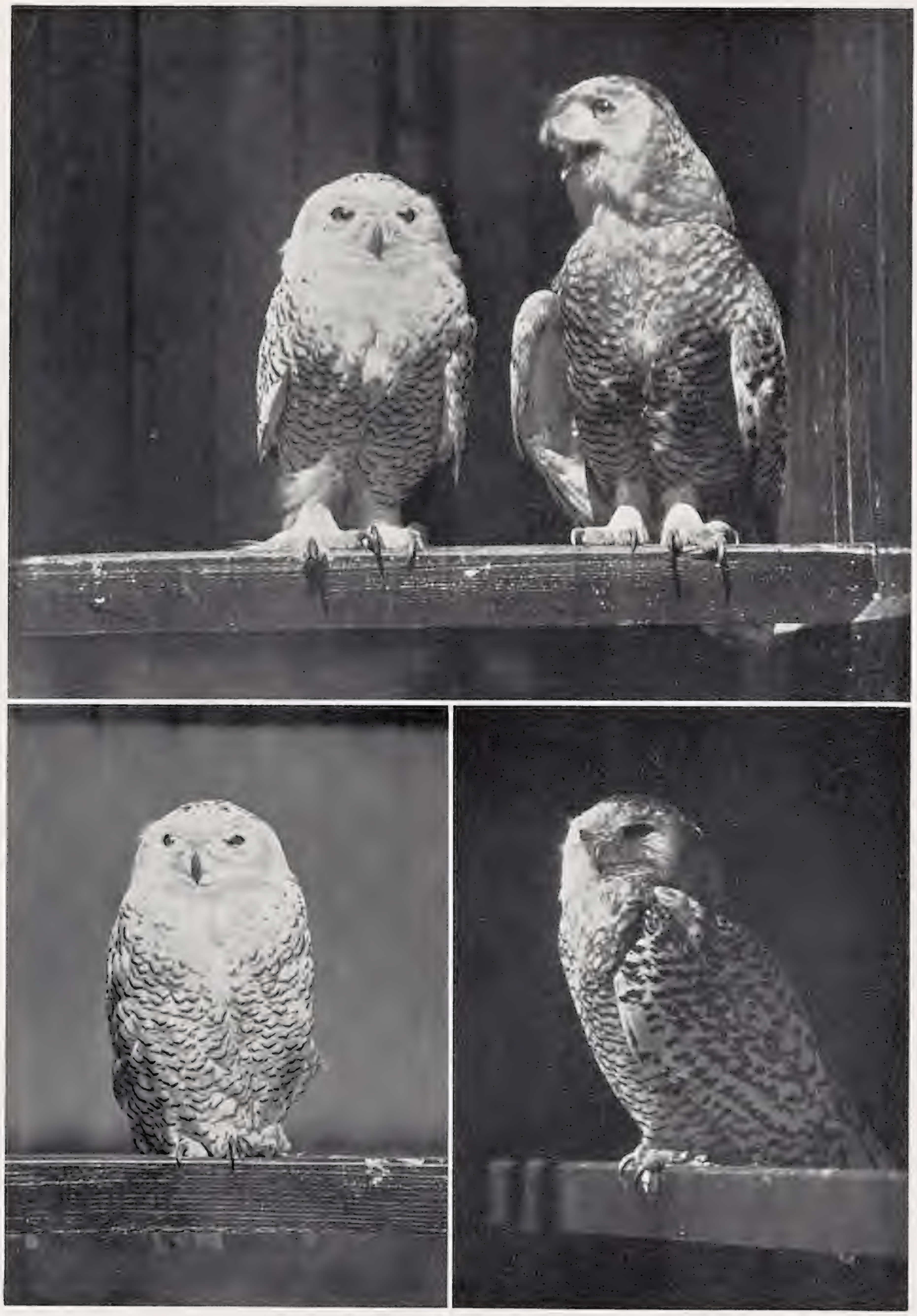
Cape Eagle Owl. *Bubo capensis capensis* Smith. This is the common eagle owl of Natal and the Cape Province of Africa. It is considerably smaller than the eagle owl of Europe and is further distinguished by the cross barring of the lower plumage. The specimen figured has been living in the Zoological Park since September 10, 1920.



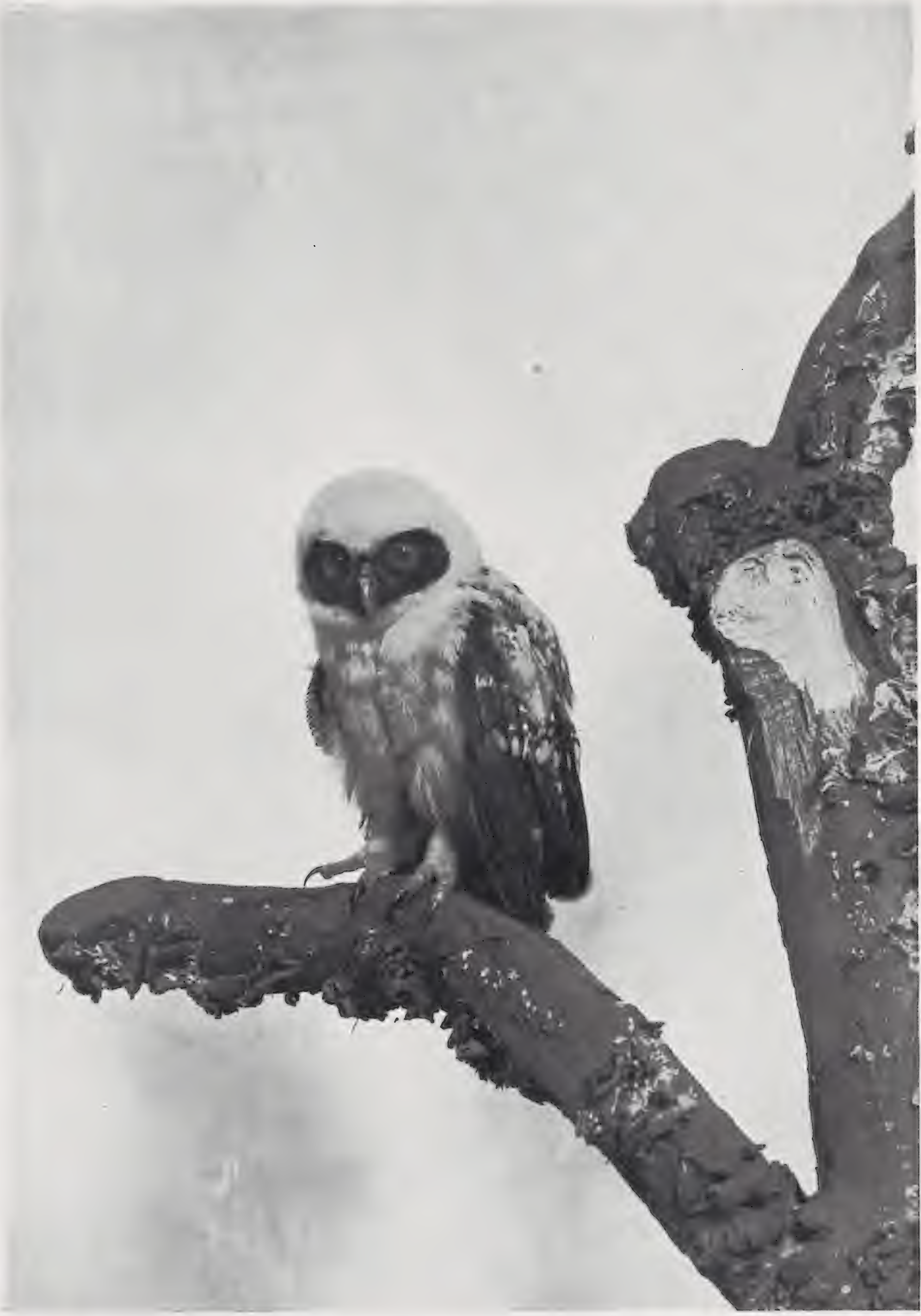
Milky Eagle Owl. *Bubo lacteus* (Temm.). The great size of this bird and its soft-toned gray plumage mark it as among the finest of all the owls. It is further distinguished by its dark irides, in contrast to the hard, yellow orbs of most of its congeners. The Milky Eagle Owl inhabits most of Africa, from Senegal to the Cape Province, except for the heavy forest regions of the west, but it is nowhere common.



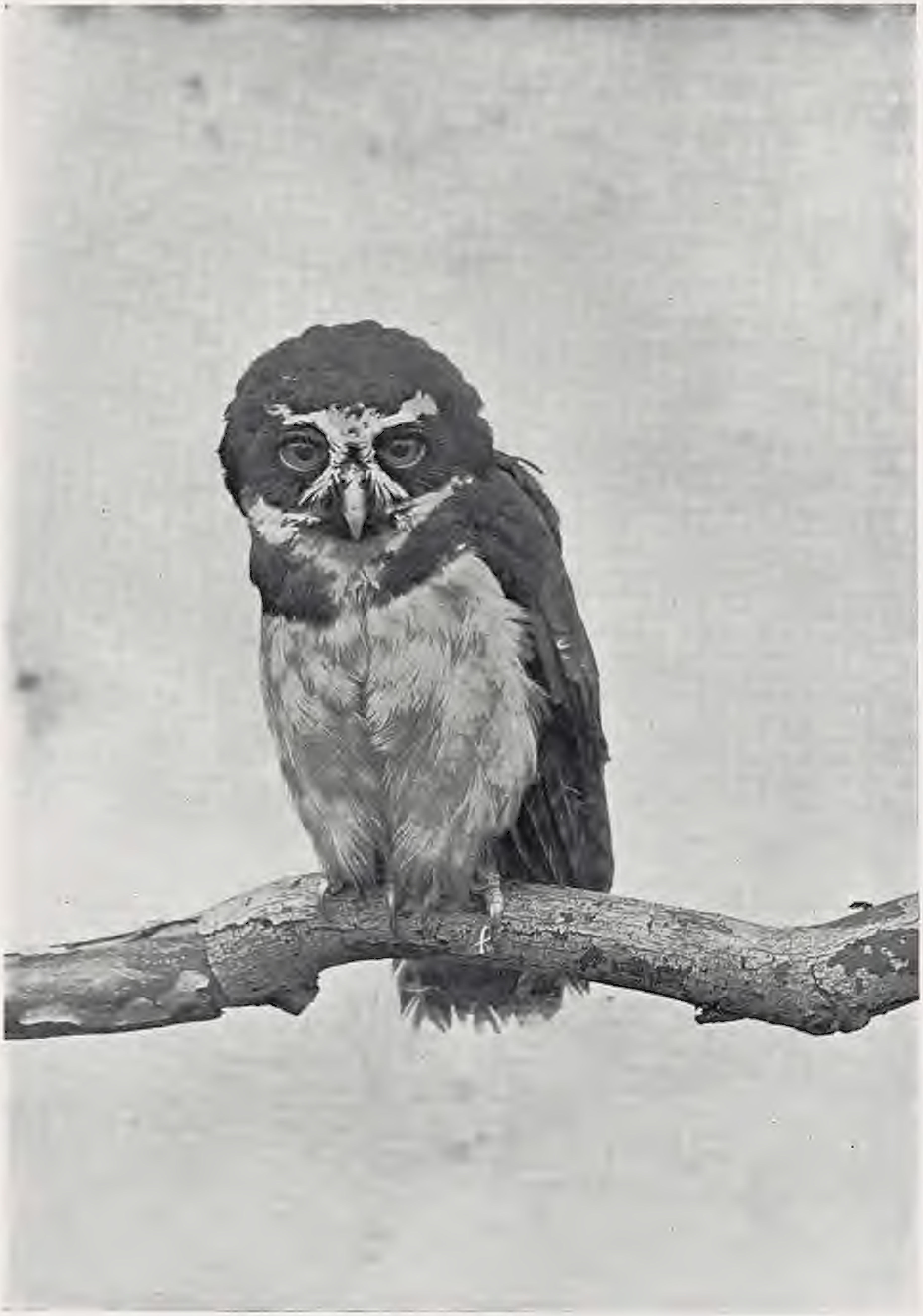
Milky Eagle Owl. *Bubo lacteus* (Temm.). This species has always been rare in captivity and the specimen figured in these photographs is only the third to be included in our collection. In spite of the tropical climate that prevails throughout most of its range, it is indifferent to the low temperatures that often occur during New York winters.



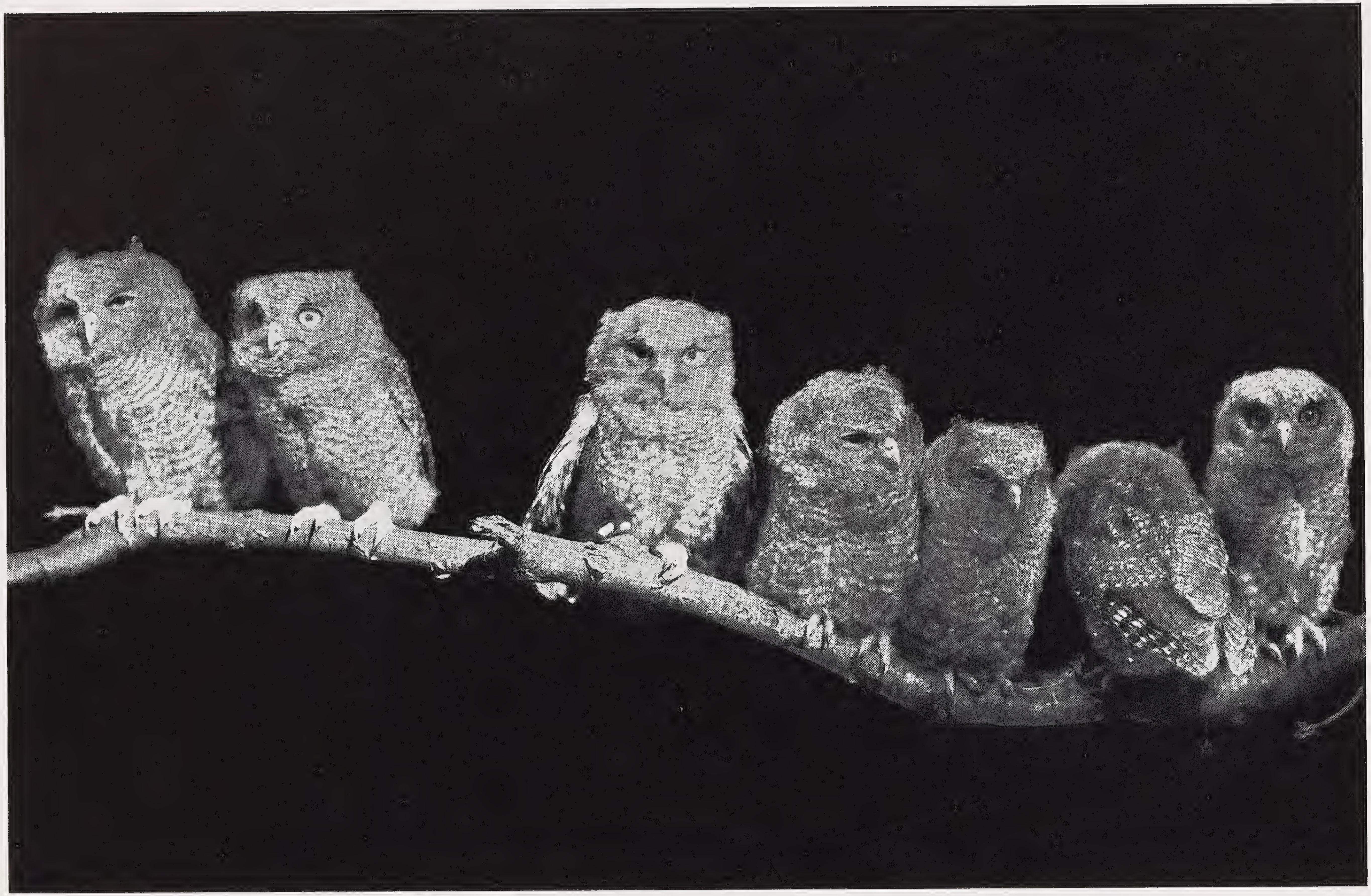
Snowy Owl. *Nyctea nyctea* (Linn.). The Snowy Owl nests in the circumpolar regions, moving southward during the winter. In the United States, it has been recorded as far south as Texas. This owl is diurnal in habit, hunting and feeding during daylight hours. It is extremely swift on the wing and is said to be able to capture ducks in flight.



Spectacled Owl. *Pulsatrix perspicillata perspicillata* (Lath.). Immature. When in the largely white body plumage of youth, this is the most strikingly colored of the owls. The species is found in South America, north of the Amazon, as well as in eastern Panama.
Photograph by Elwin R. Sanborn

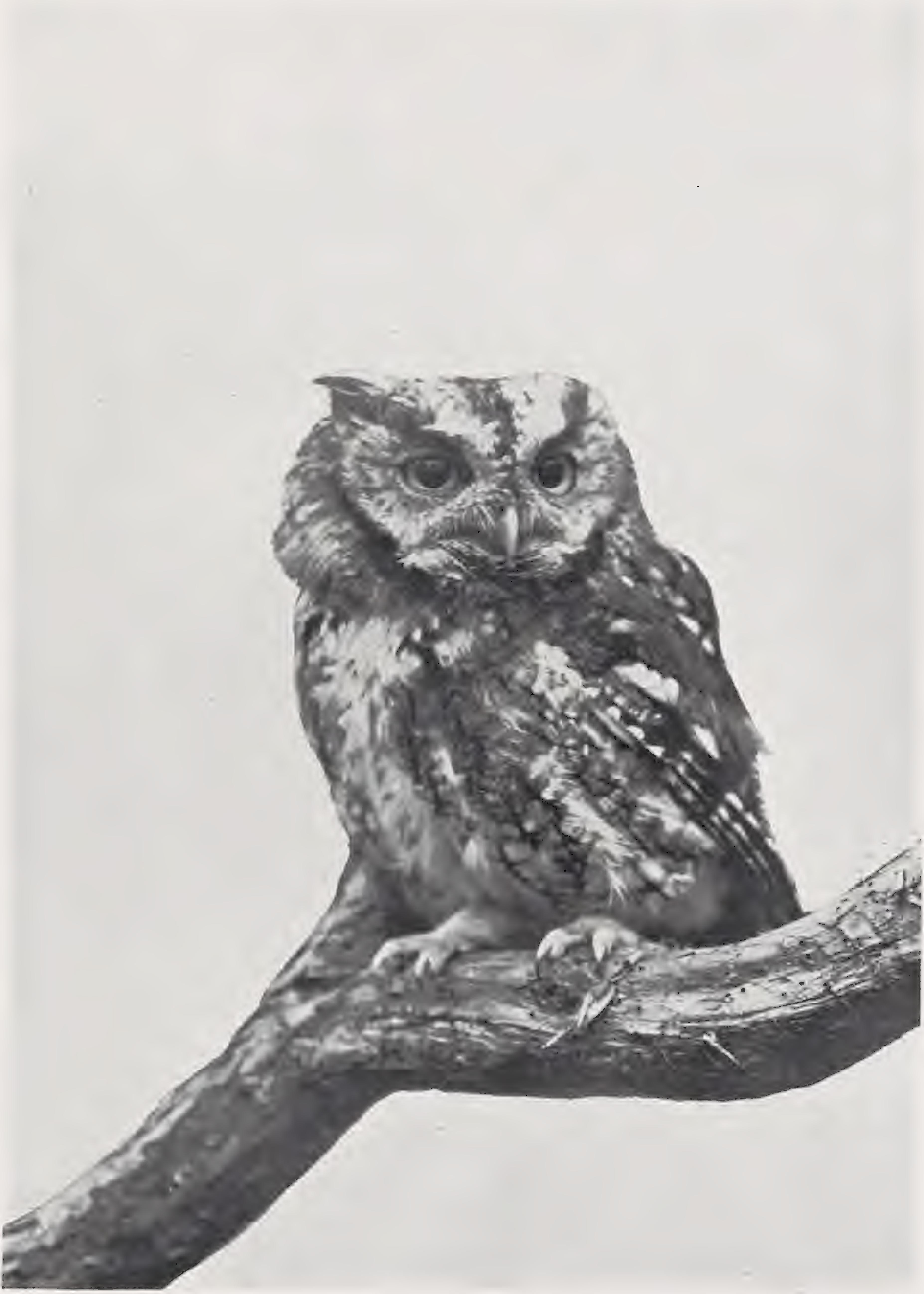


Spectacled Owl. *Pulsatrix perspicillata perspicillata* (Lath.). Adult. In the adult plumage, the coloration of the Spectacled Owl is almost reversed, but while much of the sharp contrast is lost, the bird remains extremely handsome. This tropical species thrives in captivity and has lived with us for long periods.
Photograph by Elwin R. Sanborn



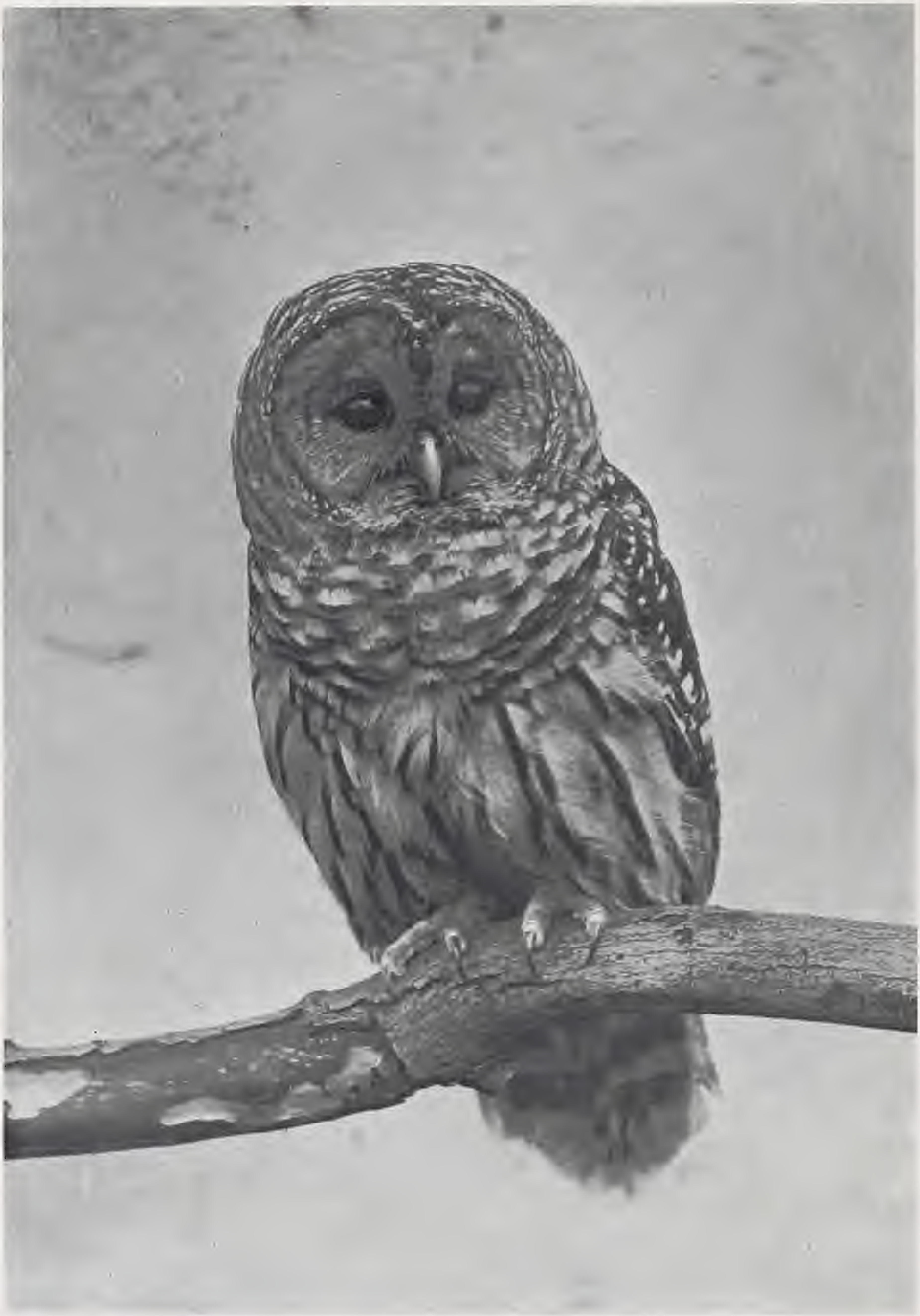
Young Screech Owls. *Otus asio naevius* (Gmel.). In the outskirts of New York City, at least, the Screech Owl is making a valiant fight against encroaching "developments." Wherever park lands or other open country give him shelter and a chance for food, he is likely to be found. He still finds a place in the "List of Wild Birds Found in the Zoological Park."

Photograph by Elwin R. Sanborn

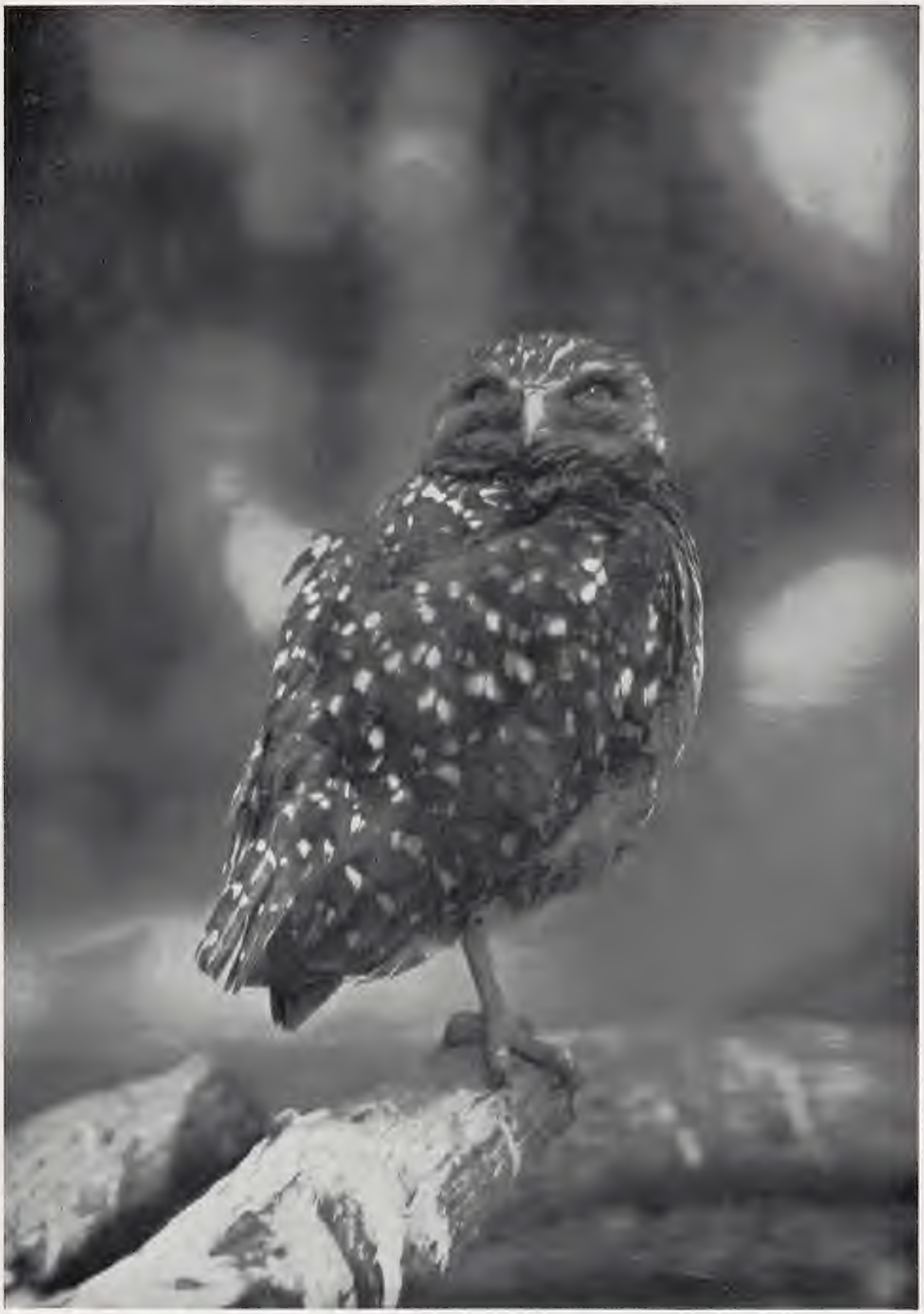


Adult Screech Owl. *Otus asio naevius* (Gmel.). The Screech Owl is essentially a sedentary bird, which no doubt accounts for its persistence, as well as for the many subspecies into which it has been divided. About fourteen forms are now recognized, ranging from New Brunswick and Ontario to Mexico and Lower California.

Photograph by Elwin R. Sanborn

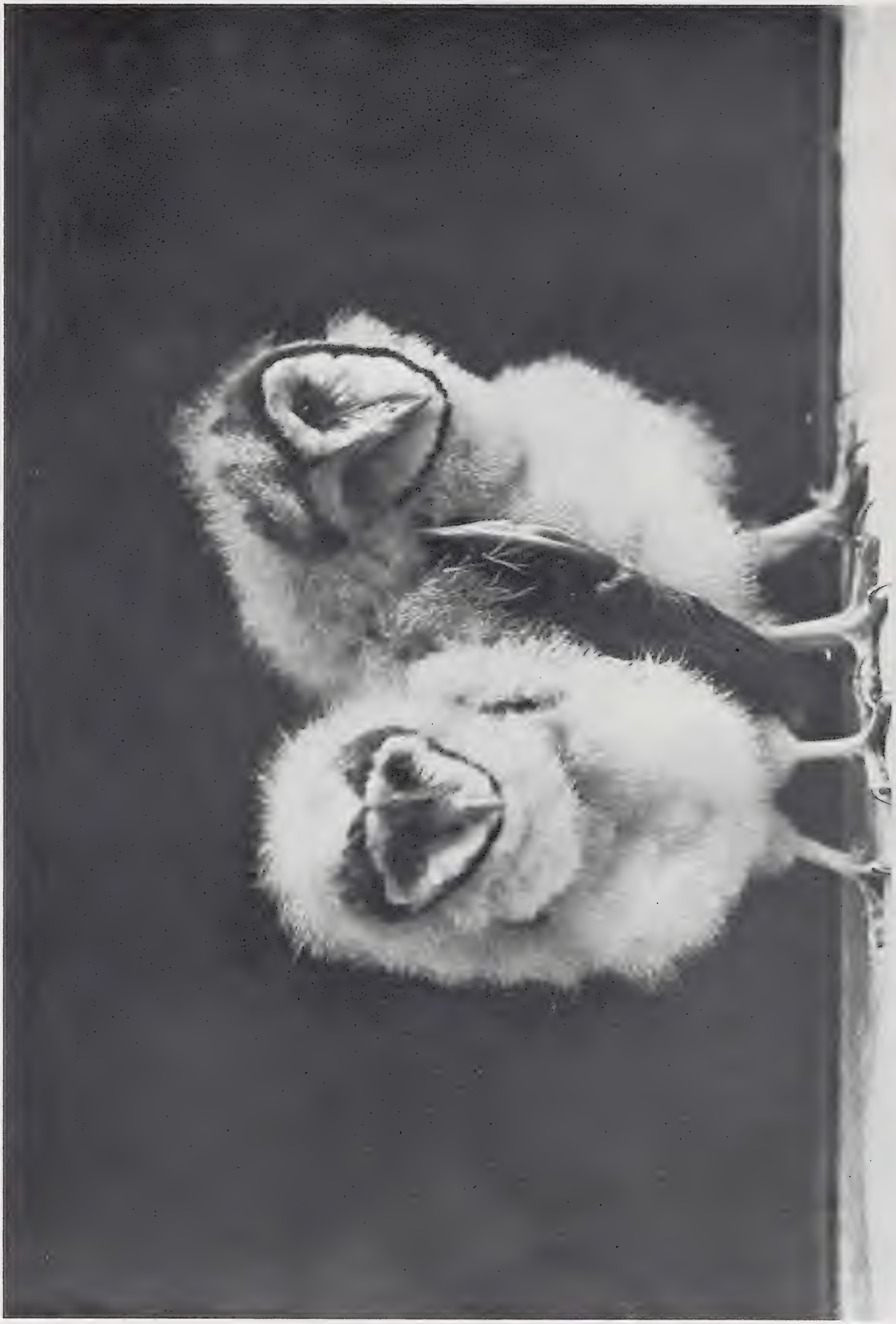


Barred Owl. *Strix varia varia* (Barton). As owls go, this is a rather fearless and confiding species, so that it has suffered, perhaps more than other owls, from thoughtless sportsmen and others, who shoot it on sight. It is undoubtedly an extremely beneficial bird, feeding largely on rodents. Hardly a winter passes without at least one Barred Owl being recorded as a visitor to the Zoological Park. Photograph by Elwin R. Sanborn



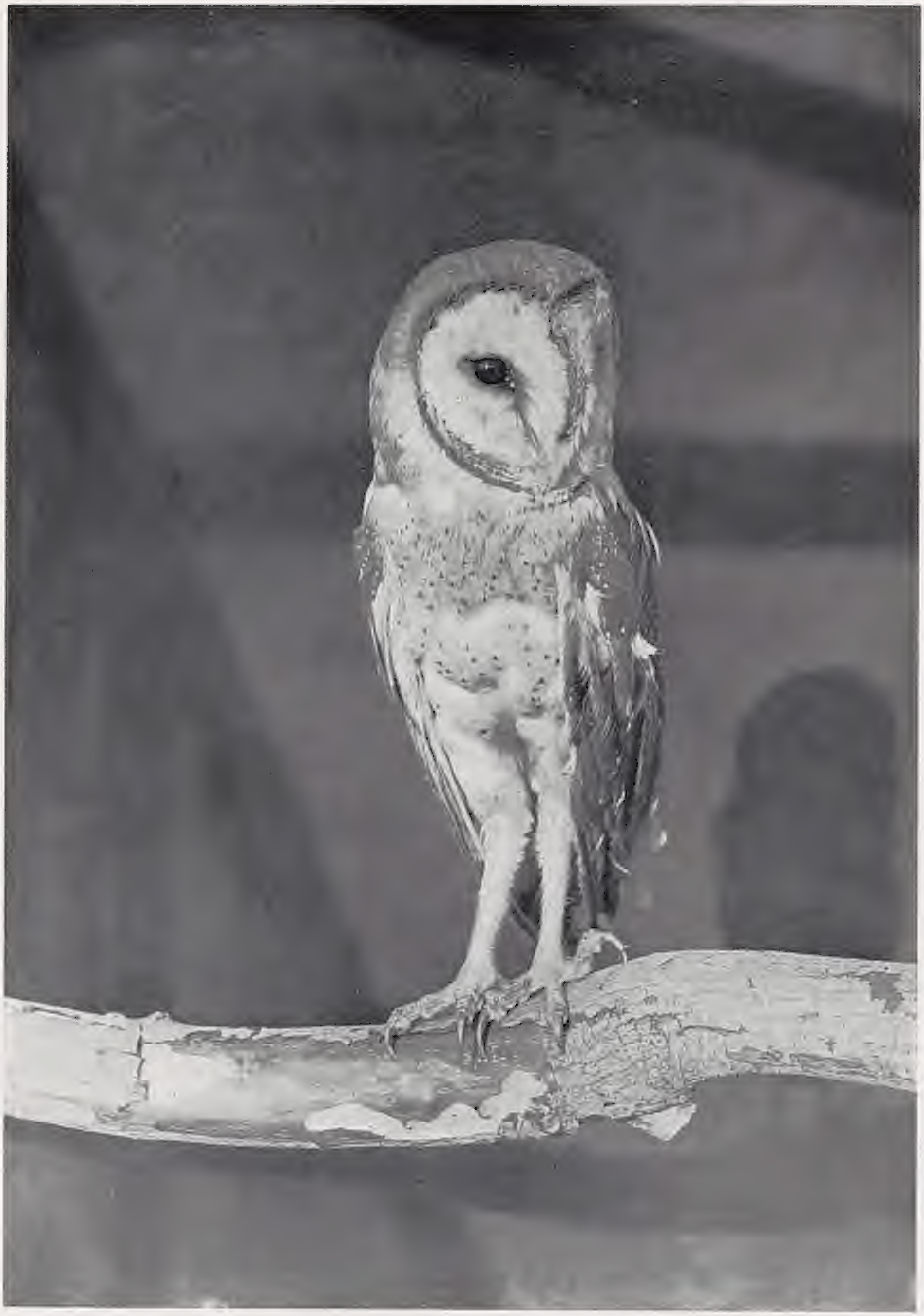
Western Burrowing Owl. *Speotyto cunicularia hypogaea* (Bonap.). A typical feature of the western plains, this little owl is often found as a resident in colonies of prairie dogs. This association has given rise to the pleasant myth that the rightful owners of the burrows, with both owls and rattlesnakes in the role of guests, form a "happy family." Unquestionably, both of the latter occupy the position of demons, rather than friends.

Photograph by Elwin R. Sanborn



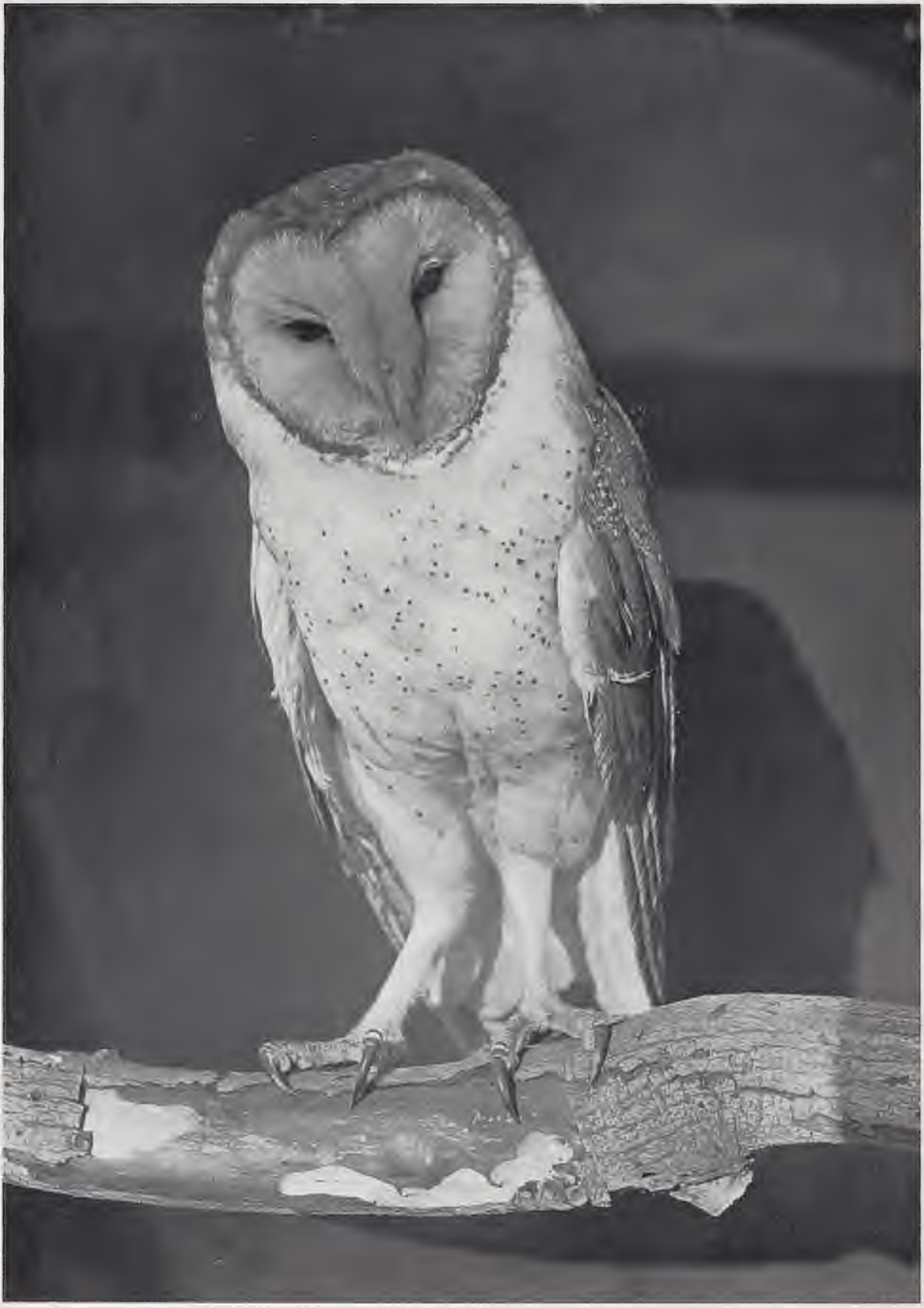
Young American Barn Owls. *Tyto alba pratincola* (Bonap.). While all owls arouse great curiosity and interest whenever they emerge from hiding long enough to be seen, none among them can equal the barn owls in this particular. The young, especially, clothed in furry down, are most unbirdlike in both appearance and actions.

Photograph by Elwin R. Sanborn



American Barn Owl. *Tyto alba pratincola* (Bonap.). Adult. Known commonly as the "Monkey-faced Owl," this bird is found throughout the United States and Mexico, wintering south to Ecuador. It is an extremely secretive species, but occasionally living specimens are captured, resulting in an immediate offer to the nearest zoo, of a "strange bird with a face like a monkey's, which no one has ever seen before."

Photograph by Elwin R. Sanborn



European Barn Owl. *Tyto alba alba* (Scop.). This is the common Barn Owl of Europe. Its weird expression, loud call-notes and ghost-like flight, have made it the subject of many fearsome beliefs and superstitions.
Photograph by Elwin R. Sanborn

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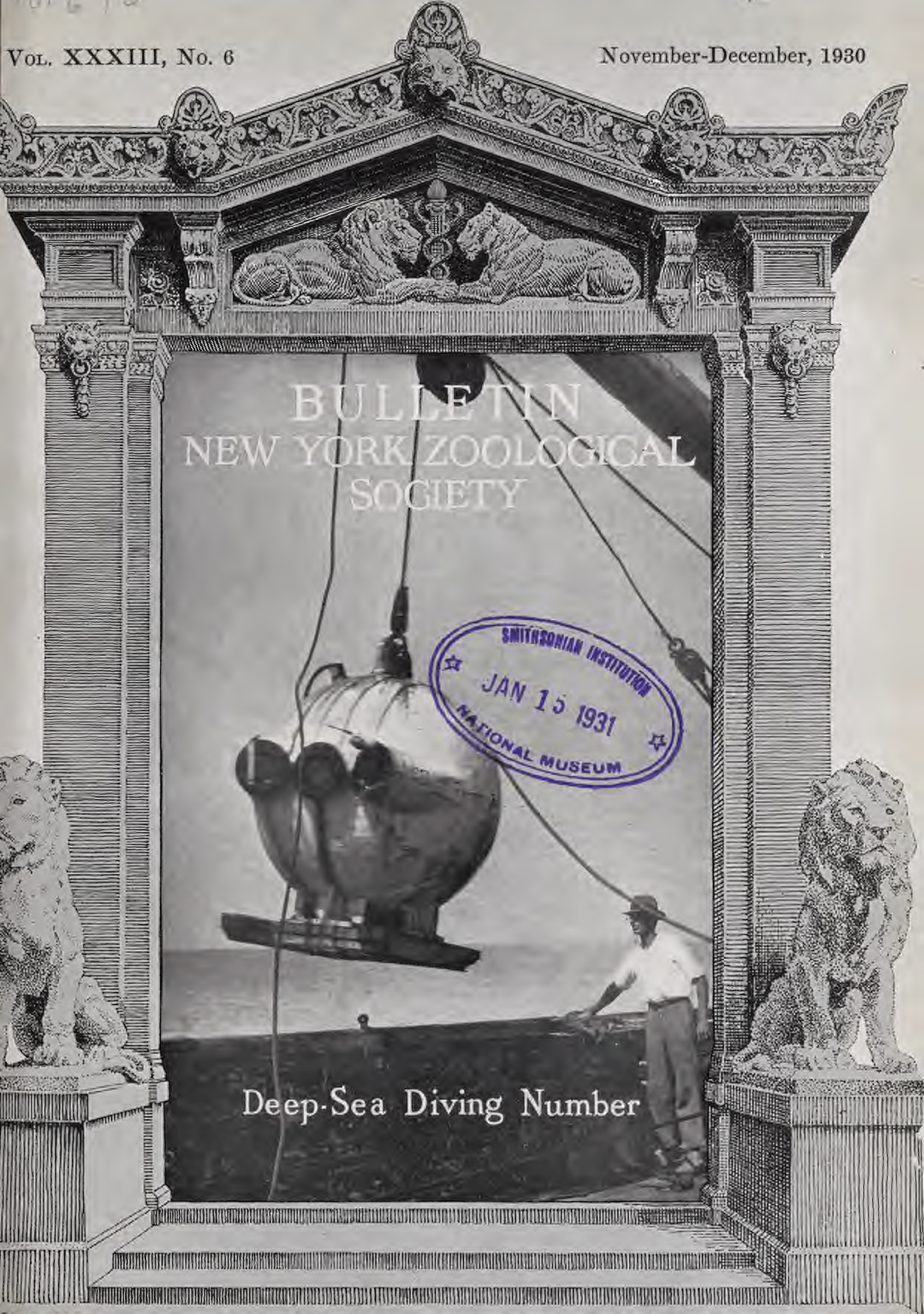

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GLORIA HOLLISTER, *Technical Associate*

Vol. XXXIII, No. 6 November-December, 1930

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The Staff of the Expedition

The staff of the second year of the Bermuda Oceanographic Expedition was as follows: William Beebe, John Tee-Van, Gloria Hollister, William K. Gregory, E. Newton Harvey, Otis Barton, E. M. Bostelmann, Jocelyn Crane, Margaret Elliott, Llewellyn Miller, Helen Tee-Van, Virginia Ziegler, Howard Barnes, Perkins Bass, John Cannon, Jack Connery, Phil Crouch, Jack Guernsey and Patten Jackson. The work carried on by each will be indicated in a coming Bulletin, which will contain a résumé of the Zoological Society's Second Expedition to Nonsuch in 1930.

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BULLETIN

New York Zoological Society

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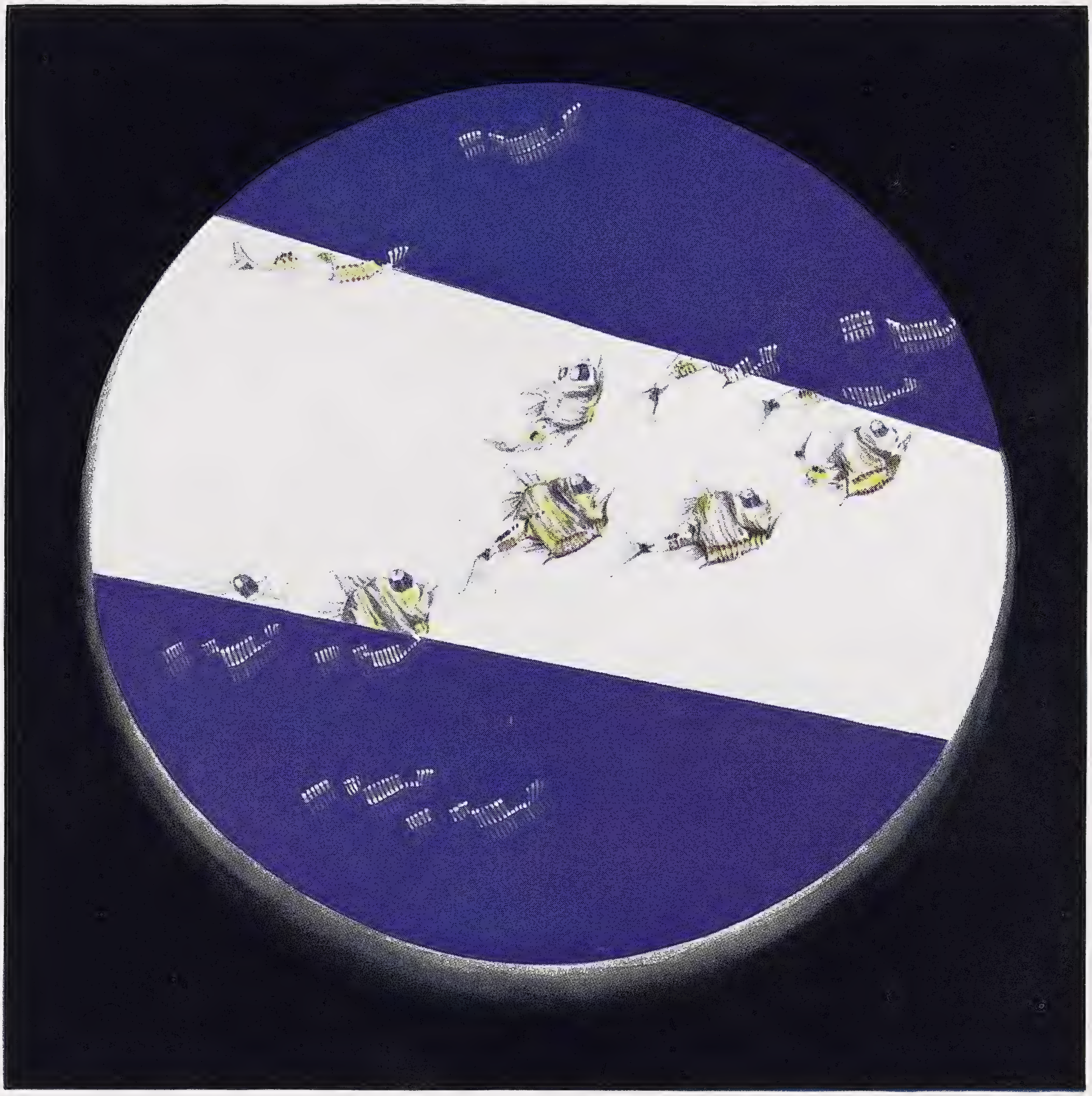


Looking out through the six-inch, fused quartz window of the bathysphere, 800 feet below the surface. The water is blackish-blue; the electric light cuts sharply through the centre; a school of Silver Hatchet-fish *(Argyropelecus hemigymnus)* is passing, showing against the blue as isolated, moving groups of lights, and against the electric beam as silvery fish with great telescopic eyes. Painted by E. M. Bostelmann.

BULLETIN
NEW YORK ZOOLOGICAL SOCIETY

Published by the New York Zoological Society

Vol. XXXIII November-December, 1930 No. 6

The Second Bermuda Oceanographic Expedition

Thirteenth Expedition of the Department of Tropical Research of the New York Zoological Society

William Beebe, *Director*

THE TEN HIGH LIGHTS IN 1930
of the Department of Tropical Research

1—That our deep sea work of 1929 was satisfactory to our sponsors.

2—That it was completed without a deficit.

3—That we now have a pressure depth gauge which accurately and minutely records the time and course of any net from the surface down to one thousand fathoms and back again.

4—That we were able to descend a quarter of a mile into the open ocean, to observe strange creatures, and to return safely.

5—That we went through the hurricane of August 26th with a maximum of thrill and a minimum of damage.

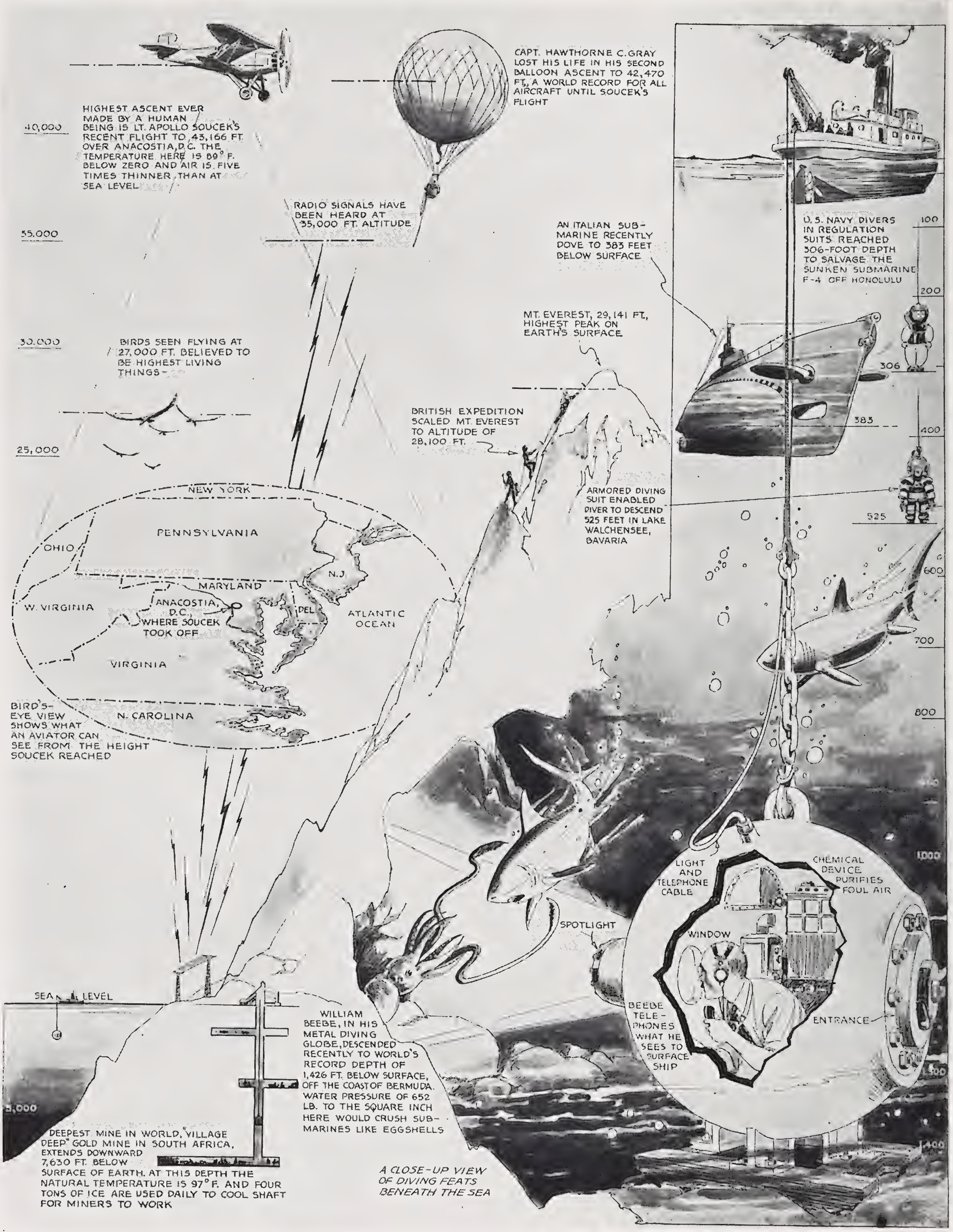
6—That of ten young enthusiasts on our staff this year every one made good in his or her field of work.

7—That the Zoological Society, on our fifteenth birthday, has given us a new laboratory in the Zoological Park.

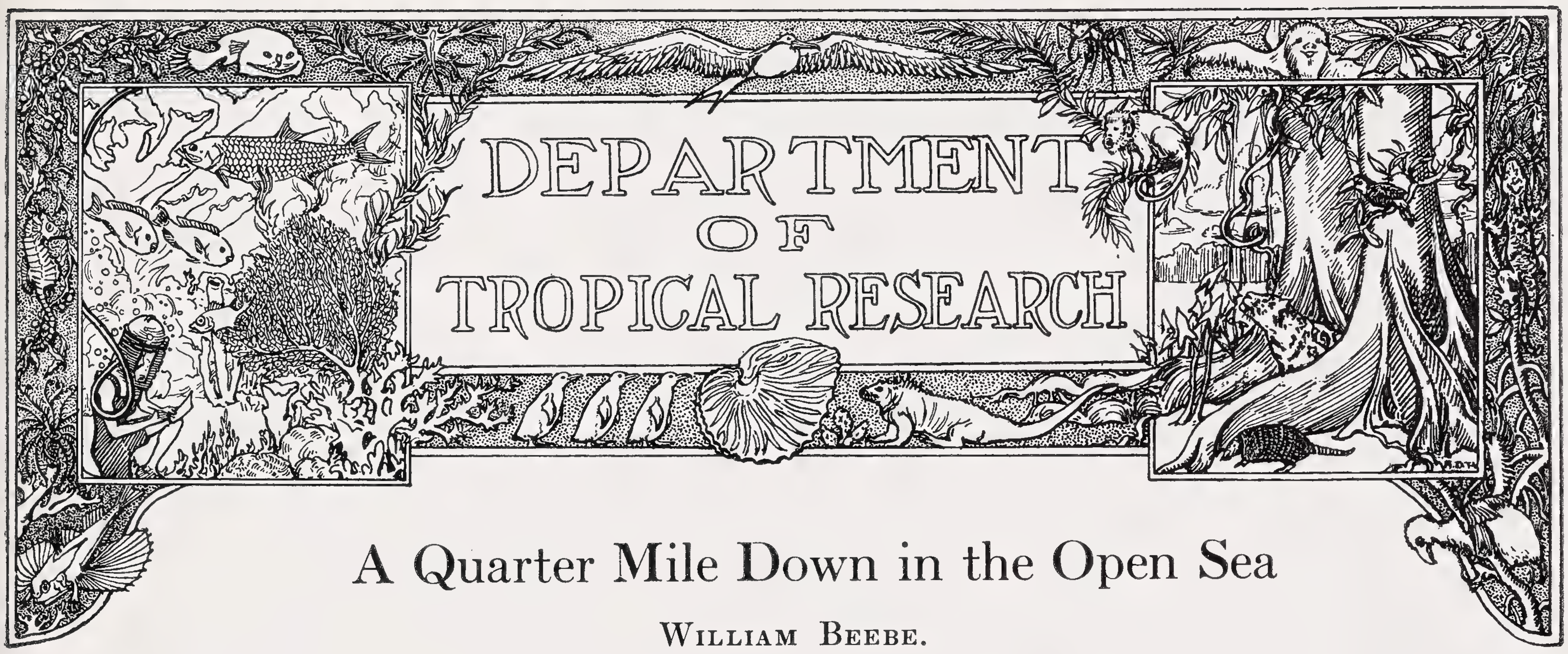
8—That the Government of Bermuda abates nothing in its constant expression of warm friendship.

9—That thus far we have drawn 976 nets and our last catalogue number was 19820.

10—That we have been promised support for a third season's work on Nonsuch.


HIGHEST ASCENT EVER MADE BY A HUMAN BEING IS LT. APOLLO SOUCEK'S RECENT FLIGHT TO 43,166 FT. OVER ANACOSTIA, D.C. THE TEMPERATURE HERE IS 89° F. BELOW ZERO AND AIR IS FIVE TIMES THINNER THAN AT SEA LEVEL
40,000
CAPT. HAWTHORNE C. GRAY LOST HIS LIFE IN HIS SECOND BALLOON ASCENT TO 42,470 FT., A WORLD RECORD FOR ALL AIRCRAFT UNTIL SOUCEK'S FLIGHT
RADIO SIGNALS HAVE BEEN HEARD AT 35,000 FT. ALTITUDE
55.000
AN ITALIAN SUBMARINE RECENTLY DOVE TO 383 FEET BELOW SURFACE
U.S. NAVY DIVERS IN REGULATION SUITS REACHED 306-FOOT DEPTH TO SALVAGE THE SUNKEN SUBMARINE F-4 OFF HONOLULU
100
200
306
383
400
525
600
700
800
1000
1300
1400
MT. EVEREST, 29,141 FT., HIGHEST PEAK ON EARTH'S SURFACE
30.000
BIRDS SEEN FLYING AT 27,000 FT. BELIEVED TO BE HIGHEST LIVING THINGS
BRITISH EXPEDITION SCALED MT. EVEREST TO ALTITUDE OF 28,100 FT.
25,000
ARMORED DIVING SUIT ENABLED DIVER TO DESCEND 525 FEET IN LAKE WALCHENSEE, BAVARIA
NEW YORK
PENNSYLVANIA
OHIO
N.J.
MARYLAND
W. VIRGINIA
ANACOSTIA, D.C., WHERE SOUCEK TOOK OFF
DEL.
ATLANTIC OCEAN
VIRGINIA
N. CAROLINA
BIRD'S-EYE VIEW SHOWS WHAT AN AVIATOR CAN SEE FROM THE HEIGHT SOUCEK REACHED
LIGHT AND TELEPHONE CABLE
CHEMICAL DEVICE PURIFIES FOUL AIR
WINDOW
SPOTLIGHT
BEEBE TELEPHONES WHAT HE SEES TO SURFACE SHIP
ENTRANCE
SEA LEVEL
WILLIAM BEEBE, IN HIS METAL DIVING GLOBE, DESCENDED RECENTLY TO WORLD'S RECORD DEPTH OF 1,426 FT. BELOW SURFACE, OFF THE COAST OF BERMUDA. WATER PRESSURE OF 652 LB. TO THE SQUARE INCH HERE WOULD CRUSH SUBMARINES LIKE EGGSHELLS
5,000
DEEPEST MINE IN WORLD, "VILLAGE DEEP" GOLD MINE IN SOUTH AFRICA, EXTENDS DOWNWARD 7,630 FT. BELOW SURFACE OF EARTH. AT THIS DEPTH THE NATURAL TEMPERATURE IS 97° F. AND FOUR TONS OF ICE ARE USED DAILY TO COOL SHAFT FOR MINERS TO WORK
A CLOSE-UP VIEW OF DIVING FEATS BENEATH THE SEA

Man's Greatest Ups and Downs. (*Courtesy of Popular Science Monthly.*)



A Quarter Mile Down in the Open Sea

WILLIAM BEEBE.

A CERTAIN day and hour and second are approaching rapidly when a human face will peer out through a tiny window and signals will be passed back to companions, or to breathlessly waiting hosts on earth, with such sentences as:

"We are above the level of Everest."

"Can now see the whole Atlantic coastline."

"Clouds blot out the earth."

"Temperature and air pressure have dropped to minus minus."

"Can see the whole circumference of Earth."

"The moon appears ten times its usual size."

"We now———" etc.

Both by daylight and by moonlight I have looked down on the earth from a height of over three miles, so I know the first kindergarten sensations of such a trip. But until I actually am fastened down into some futuristic rocket and start on a voyage into interstellar space, I shall never experience such a feeling of complete isolation from the surface of the planet Earth as when, a few months ago, I dangled in a hollow pea on a swaying cobweb a quarter of a mile below the deck of a ship rolling in mid-ocean.

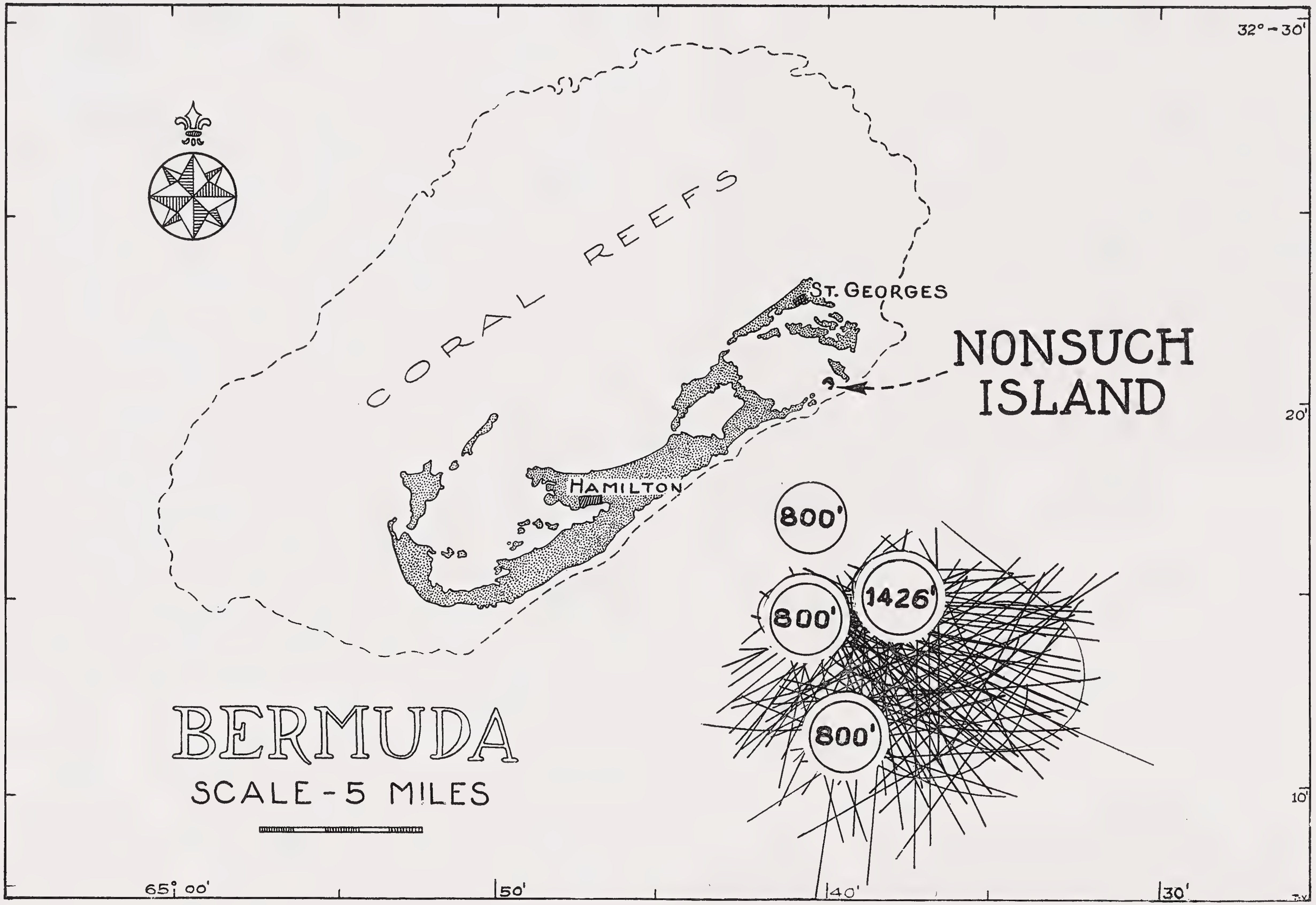
* * * *

When I mapped out a quarter of a square mile in the British Guiana jungle for intensive study my activities were more or less confined to the two planes of space on the jungle floor. I could go ahead or backward or to either side, but upward I could only look through my glasses, or send shot hurtling through the branches to bring down a bird or some creature of the trees. Occasionally I climbed laboriously up a tree-trunk on a ladder of driven spikes, or shot an arrow carrying a line over a lofty limb, later to be hauled up with a pulley and tackle for a period of brief observation.

In our present deep-sea work off Nonsuch, the conditions are much the same but inverted. The tug *Gladisfen* can steam toward any point of the compass, but to gain knowledge and obtain specimens of the little-known life-zones beneath our keel, we can only lower weights on a wire and record the depth of the bottom; or reversing thermometers and automatically closing bottles for temperatures and tiny samples of water from deep down, or finally we can send down dredges and nets and bring up a modicum of life from bottom or mid-water.

As far as actually descending ourselves, up to this year we have had to be content with donning a helmet and walking about arm in arm with a hoseful of air a few fathoms beneath the surface. This would be comparable to climbing among the branches of a fallen tree in the jungle. But we have recently descended far beneath the levels at which, up to the present time, human life has been possible.

For more than a year Mr. Otis Barton and I have been in frequent consultation concerning the possibility of a steel sphere, large and strong enough to permit us to enter, keep ourselves alive, to descend into, and return from, the depths of the ocean. Many years ago I used to talk for hours with Colonel Theodore Roosevelt about such a plan, and I have a rough draw-



Map of Bermuda, showing the island of Nonsuch, the location of the four deep-sea dives in the bathysphere, and the snarl of daily net hauls through the eight-mile submarine area. Drawn by John Tee-Van.

Captain Darrell, Dr. Beebe and Mr. Tee-Van on the upper deck of the *Gladisfen.* While the nets are being drawn, watch must be kept on the sea, sky, currents, the angle of the wire and its tension, and the ocean scanned for sargassum weed, dolphins, whales and giant squids.

ing of a sphere which he made one evening at Sagamore Hill. We worked out many details, but never carried it to completion.

For the inception and financing of the present sphere Otis Barton deserves full credit. He has devoted a great deal of time and money to it, while I could contribute only my belief and faith and the keenest interest in the scientific results of the adventure. I do not think that either of us ever for a moment thought of the possibility of failure; Barton's faith was sustained by the mechanical knowledge of the great percentage of safety in the various details of the apparatus, and my hopes of seeing a new world of life left no opportunity for worry about possible defects in the means to the end.

As the great metal chamber took shape, we found the need of a definite name. We spoke of it casually and quite incorrectly as tank and cylinder and bell. One day, when I was writing the name of a deep-sea fish—*Bathytroctes*—the appropriateness of the Greek prefix occurred to me: I coined the word *Bathysphere,* and the name has stuck.

In April I took my staff to Nonsuch, opened the laboratory, got the tug Gladisfen into harness again, and was in full swing of shallow and deep-sea work by the time the sphere was ready for operation. We then joined forces and found that our various contributions to the attempt dovetailed perfectly together.

Barton had the steel sphere, 3,500 feet of seven-eighths-inch non-twisting steel cable, a half mile of solid rubber hose containing telephone and electric light wires and the multitude of necessary extras. I was able to provide my great seven-ton Arcturus winch and sheaves, and the Gladisfen for towing out to sea, and my staff for cooperation in the actual working. The great open deck of the barge "Ready" had been furnished with a stout mast and yard, and two boilers for working the winches, and when the bathysphere was hoisted on board we were ready for action. I had the barge towed out and anchored near Nonsuch, and then we watched sea and sky and barometer, praying for propitious weather.

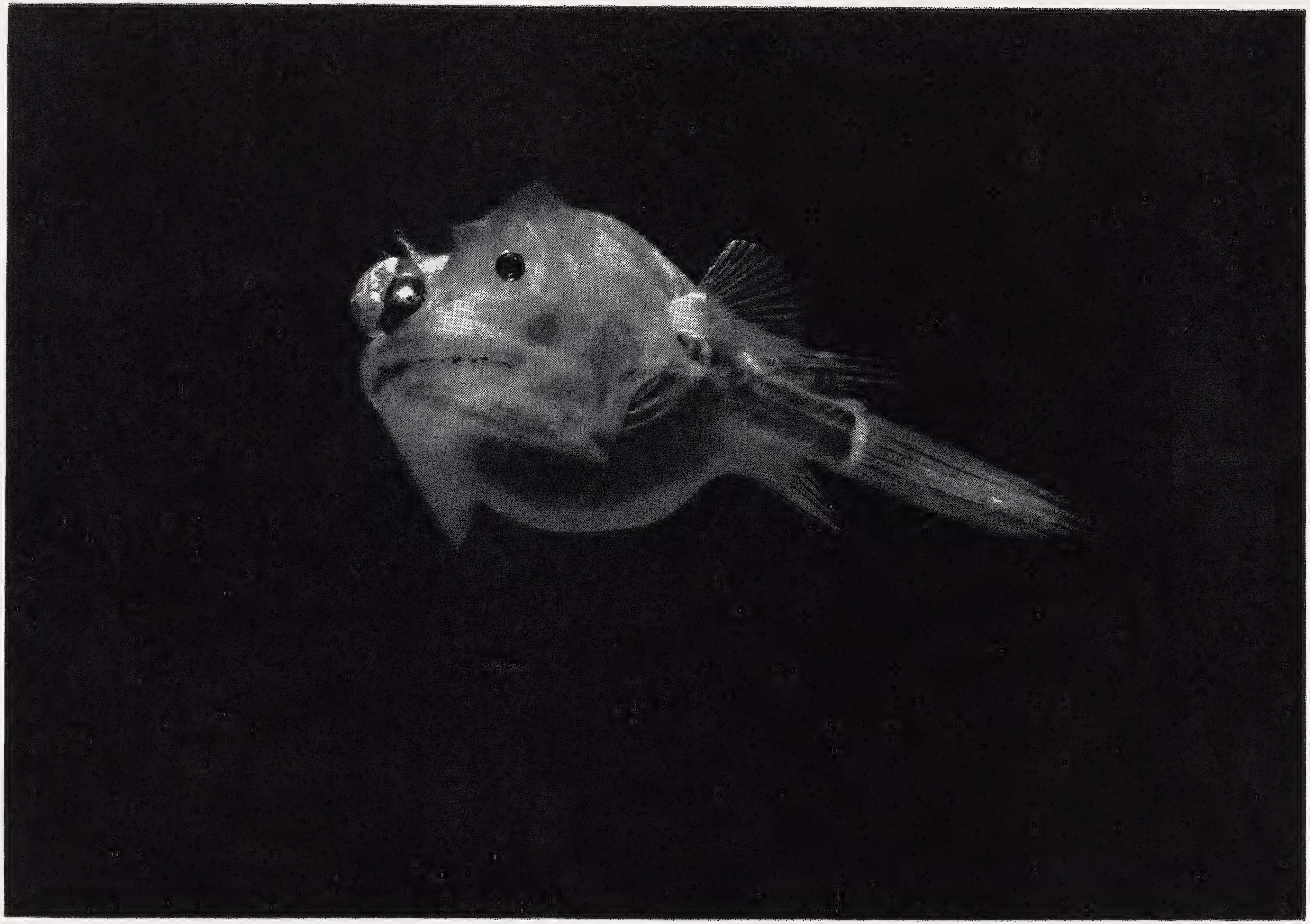
A young gale blew itself out, and on June 3rd, the sun rose on a calm, slowly heaving sea. We ran up the prearranged flag signal and the working crew saw it from St. Georges and put out. On this day we only made a trial submergence with the bathysphere empty, to test the working of the crew and the whole apparatus. It was let down 2000 feet, and when brought up there were forty-five turns of the hose about the cable. These we freed after long and tedious work, and as it afterward turned out, this tangling was due to the inevitable twists of the cable when first wound upon the drum. We devised a new system of clamps, and returned well satisfied with the condition of the bathysphere after its long downward journey.

June 6th was the next calm day, and we were all on board at 7:30. The *Gladisfen* steamed close alongside, threw us the towrope and began pulling us steadily ahead. We left Nonsuch behind and describing a great curve around the reefs, headed out to sea through Castle Roads. The great jagged cliffs towered high on both sides, and on their summits the ruined battlements of the three forts frowned down upon us, as weather-worn as the cliffs themselves. I wondered what old Governor Richard Moore would have said, three hundred and odd years ago, leaning his elbows on the parapet, if he could have watched our strange procession steaming past. In all likelihood, the steaming part would have mystified and interested him far more than our chief object.

As we cleared the outer head of Brangmans, we felt the first gentle heave and settling of the swell of the ocean, and in a few minutes the foam-ringed mass of Gurnet Rock passed astern, and we steered south straight into the open sea. An hour later the angle of the two lighthouses showed that we were about eight miles off shore, with a generous mile of water beneath us. Choosing a favorable spot under such conditions is much like looking around and trying to decide on the exact location of the North Pole. I think it was Dooley who said that finding the North Pole was like sitting down on the ice anywhere. And so I felt when they all awaited my signal to stop. I looked about, could detect no unusually favorable swell or especially satisfying wave, so I resorted to a temporal decision, and exactly at 9 o'clock ordered the *Gladisfen* to stop. We headed up wind and up swell, and lowered the bathysphere again with only a motion picture camera inside. At a depth of fifteen hundred feet this was exposed by electricity and the sphere pulled up after an hour and a half submersion. There was no twisting of the hose, the windows were intact, and only a quart of water in the bottom.

We dried and cleaned it thoroughly, then put in the oxygen tanks, a shelf of calcium chloride for absorbing moisture, and another of soda lime for removing the excess of carbon dioxide from the air. I looked around at the sky and sea, and the boats and my friends, and not being able to think of any pithy saying which might echo down the ages, I did the next best thing—said nothing, crawled painfully over the steel screws of the fifteen-inch circle of the door, fell inside, and curled up on the cold, hard bottom of the sphere. This aroused me to speech, for I vividly realized the discomfort of an hour or more in such a position, and I called for a cushion. Otis Barton clambered in after me and we disentangled our legs and got set. I never realized how much room there was in the interior of a sphere four and half feet in diameter, and although the longer we were in it, the smaller it seemed to get, yet, thanks to our moderate physique, we had room and to spare. At Barton's suggestion I took up my place close to the windows, while he hitched himself up on the side of the door, where he could keep watch on the various instruments. He also put on the earphones.

As pre-arranged, John Tee-Van took charge of the deck crew, and Gloria Hollister put on the ear-phones and arranged the duplicate control electric light so that she could watch it. She dictated all our messages direct to an assistant who took them down and later transcribed them unchanged. At our signal, the four hundred pound door was hoisted and clanged into place, sliding snugly over the ten great steel bolts. Then the huge nuts were screwed on. If either of us had had time to be nervous, this would have been an excellent opportunity—carrying out Poe's idea of being sealed up, not all at once, but little by little. For after the door was screwed on there remained a four-inch round opening in the center through which we could see



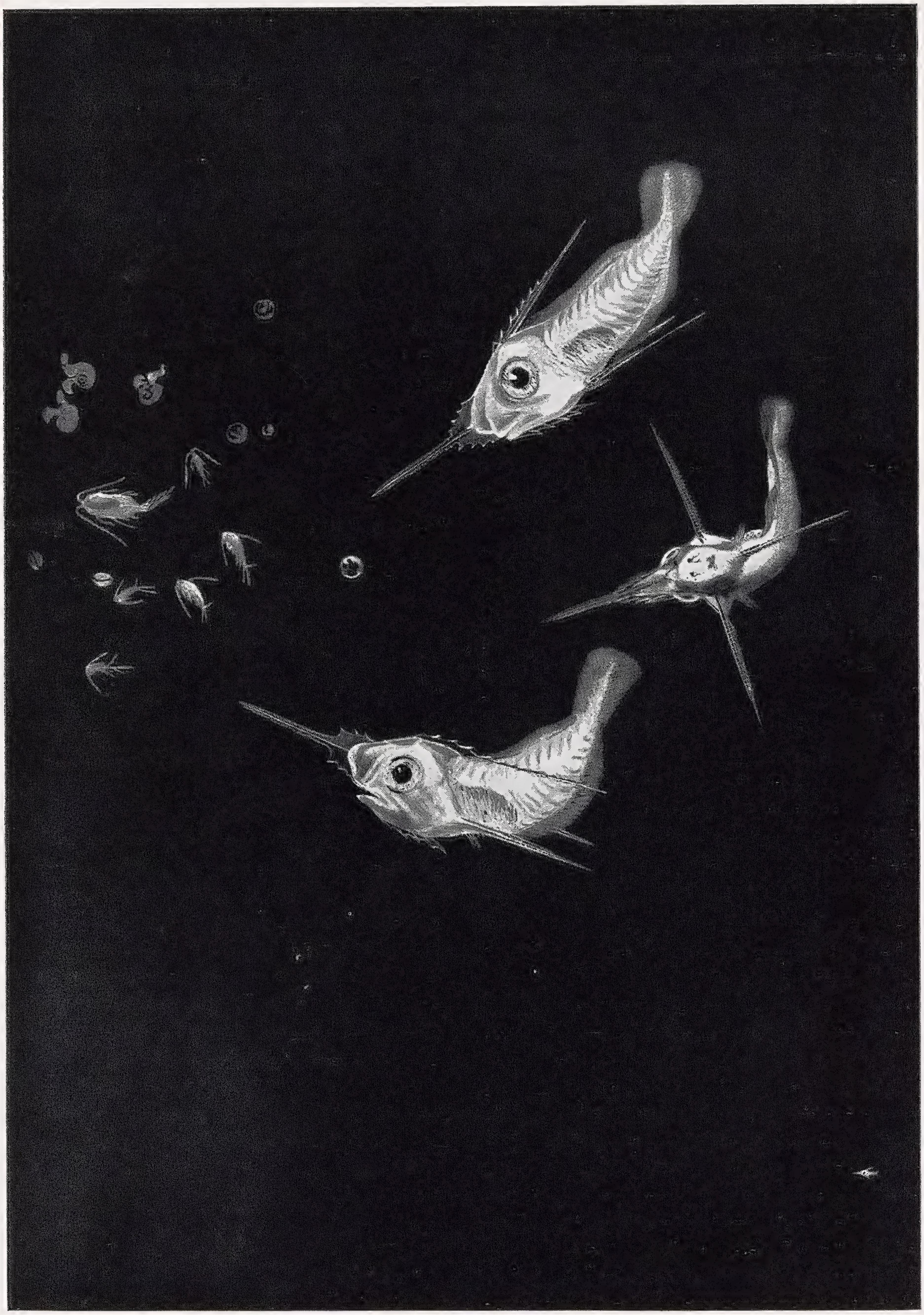
A rare, white abysmal fish *(Edriolychnus)* from 900 fathoms which lived for hours and was photographed alive. It gave forth pale green and purple light. The diminutive male of this fish has been found growing fast to the head of the female.

and talk and just slip a hand. Then this mighty bolt was screwed in place, and there began the most infernal racket I have ever heard. It was necessary, not only to screw the nuts down hard, but to pound the wrenches with hammers to take up all slack. I was sure the windows would be shattered, but having forcibly expressed our feelings through the telephone we gradually got used to the ear shattering reverberations. Then utter silence settled down, and I breathed upon and cleaned my six-inch quartz window. I could see a narrow section of the scurrying about on deck, and as we rolled I caught sight of the ultramarine sea and the *Gladisfen* dipping at the end of the slack tow rope. Faint scuffling sounds reached us now and then, and an occasional hollow beating. Then it seemed as if the steel walls fell away, and we were again free among our fellows, for a voice came down the half mile of wire coiled on the deck, and such is the human mind, that vocal connection seemed to restore physical as well as mental contact. While waiting for the take-off, Barton readjusted the phone, tested the search-light, and opened the delicate oxygen valve. He turned it until we both verified the flow as two litres a minute—that being sufficient for two people. I remembered what I had read of Houdini's method of remaining in a closed coffin for a long time, and we both began conscientiously regulating our breathing, and conversing in low tones.

Another glance through my port-hole showed Tee-Van looking for a signal from old Captain Millet. I knew that now it was actually a propitious wave or rather a propitious lack of one for which they waited. Soon Millet waved his hand, and exactly at one o'clock the winch grumbled, the wire on the deck tightened, and we felt our circular home tremble, lean over, and lift clear. Up we went to the yard-arm, then a half-score of the crew pulled with all their might and swung us out over the side. This all between two big heaving swells. We were dangling in mid-air and slowly we revolved until I was facing in toward the side of the *Ready*. And now our quartz windows played a trick on us. Twice already, in an experimental submergence we had not gauged correctly the roll of the ship or the distance outboard and the sphere had crashed into the half-rotten bulwarks. Now as I watched, I saw us swing and my eyes told me that we were much too close, and that a slightly heavier roll would crash us, windows first, into the side of the vessel. Barton could not see the imminent danger, and the next message I got was "Gloria wants to know why the Director is swearing so." By this time we had swung far out, and I realized that every word which we spoke to each other in our tiny hollow chamber was clearly audible at the other end of the wire. I sent up word that any language was justifiable at such gross neglect as to allow our window to swing back and forth only a yard from the boat. And very decisively the word came back that fifteen feet was the nearest it had ever been, and we were now twenty-five feet away. Barton looked out with me and we could hardly believe our eyes. Fused quartz is the clearest, the most transparent material in the world, and my apologies must have cost us several litres of good oxygen.

To avoid any further comment on our part, profane or otherwise, we were lowered twenty feet. I sensed the weight and sturdy resistance of the bathysphere more at this moment than at any other time. We were lowered gently but we struck the surface with a splash which would have crushed a rowboat like an eggshell. Yet within we hardly noticed the impact, until a froth of foam and bubbles surged up over the glass and our chamber was dimmed. We swung quietly while the first hose clamp was put on the cable. At the end of the first revolution the great hull of the barge came into view. This was a familiar landscape, which I have often seen from the diving helmet—a transitory, swaying reef with waving banners of seaweed, long tubular sponges, jet black blobs of ascidians and tissue-thin plates of rough-spined pearl shells. Word came down, and the keel passed slowly upward, becoming one with the green water overhead.

With this passed our last visible link with the upper world; from now on we had to depend on distant spoken words for knowledge of our depth, or speed, or the weather or the sunlight, or anything having to do with the world of air on the surface of the Earth.



Young of unknown species of deep-sea fish, armed with long, sharp spines. These soon drop off, and the fish assumes a more normal appearance. These young fish are one-quarter of an inch in length. Painted by E. M. Bostelmann.

A few seconds after we lost sight of the hull of the *Ready,* word came down the hose that we were at fifty feet, and I looked out at the brilliant bluish green haze and could not realize that this was almost my limit in the diving helmet. Then "100 feet" was called out, and still the only change was a slight twilighting and chilling of the blue. As we sank slowly I knew that we must be passing the 132nd foot level, the depth where Commander Ellsberg labored so gallantly to free the men in the Submarine S-57. "200 feet" came and we stopped with the slightest possible jerk and hung suspended while a clamp was attached—a double gripping bit of brass which bound the cable and hose together to prevent twisting. Then word came down that all was clear and again I knew that we were sinking, although only by the upward passing of small motes of life in the water.

We were now very far from any touch of Mother Earth; ten miles south of the shore of Bermuda, and one and a half miles from the sea bottom far beneath us. At 300 feet, Barton gave a sudden exclamation and I turned the flash on the door and saw a slow trickle of water beneath it. About a pint had already collected in the bottom of the sphere. I wiped away the meandering stream and still it came. There flashed across my mind the memory of gentle rain falling on a window pane, and the first drops finding their way with difficulty over the dry surface of the glass. Then I looked out through the crystal clear quartz at the deep blue, and the contrast closed in on my mind like the ever deepening twilight.

Two minutes more and "400 feet" was called out; 500 feet came and passed overhead, then 600 feet where we remained for five minutes. The electric searchlight now became visible. Heretofore we could see no change whatever in the outside water when it was turned on, but now a pale shaft of yellow—intensely yellow—light shot out through the blue, very faint but serving to illuminate anything which crossed it. Most of the time I chose to have it cut off, for I wanted more than anything else to see all that I could of the luminescence of the living creatures.

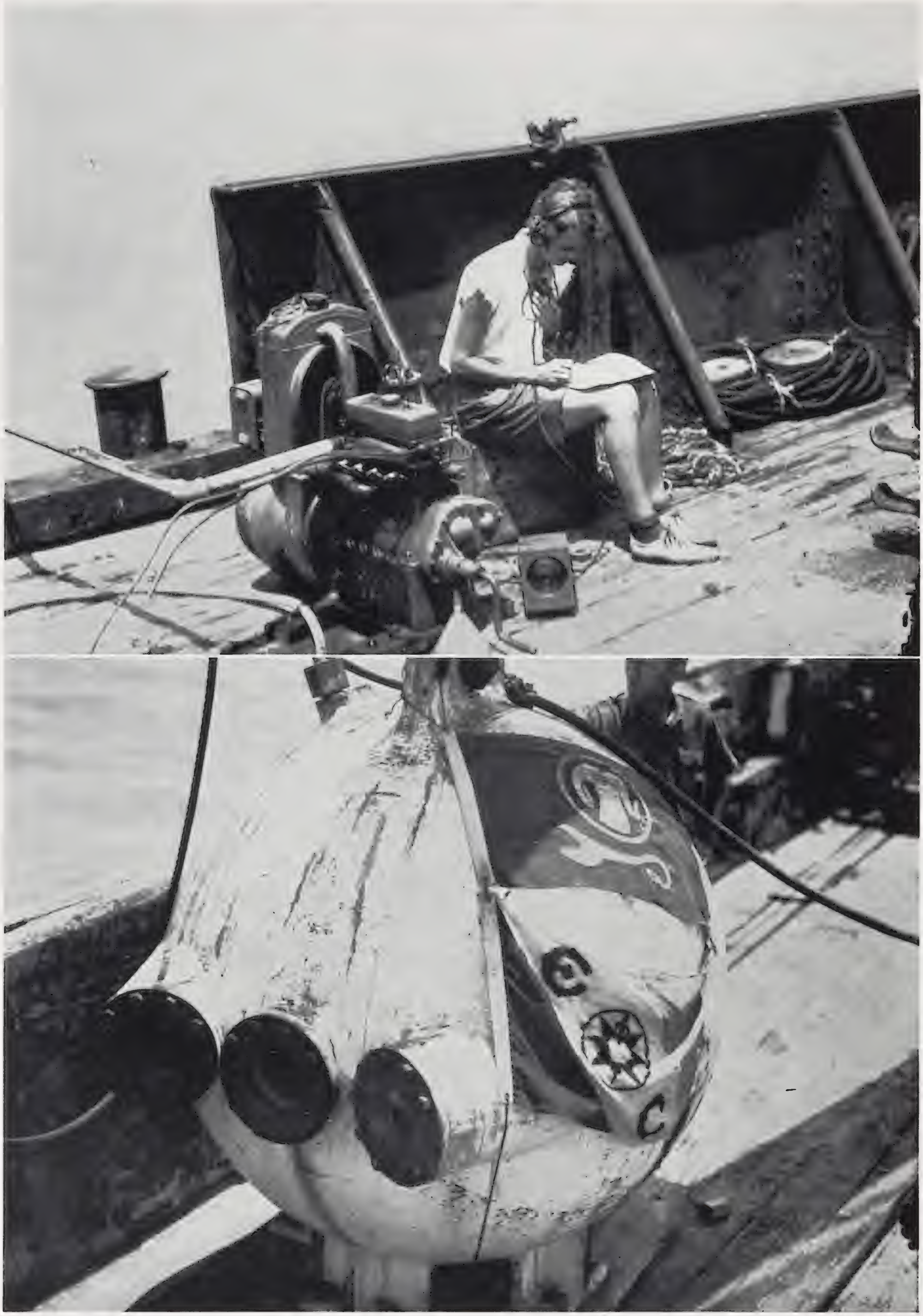
Now when I cupped my face in my hands, and stared and stared out, I began to see what a strange illumination the water at this depth possessed. In fact, the most amazing thing, that which endured most vividly in our memory was the color. My companion kept exclaiming at its brilliance and saying he could read by it, and while the general sensation reported by my excited optic nerves urged me to agree with him, yet my mind told me it was not true. I brought all my logic to bear, I put out of mind the excitement of our position in watery space and tried to think sanely of comparative color, and I failed utterly, I flashed on the searchlight, which seemed the yellowest thing I have ever seen, and let it soak into my eyes, yet the moment it was switched off, it was like the long vanished sunlight—it was as though it never had been—and the blueness of the blue, both outside and inside our sphere seem to pass materially through the eye into our very beings. This is all very unscientific; quite worthy of being jeered at by optician or physicist, but there it was. I was excited by the fishes that I was seeing perhaps more than I have ever been by other organisms, but it was only an intensification of my surface and laboratory interest: I have seen strange fluorescence and ultra violet illumination in the laboratories of physicists: I recall the weird effects of color shifting through distant snow crystals on the high Himalayas, and I have been impressed by the eerie illumination, or lack of it, during a full eclipse of the sun. But this was beyond and outside all or any of these. I think we both experienced a wholly new kind of mental reception of color impression. I felt I was dealing with something too different to be classified in usual terms.

Yet I find that I must continue to write about it, if only to prove how utterly inadequate language is to translate vividly, feeling and sensations under a condition as unique as submersion at this depth.

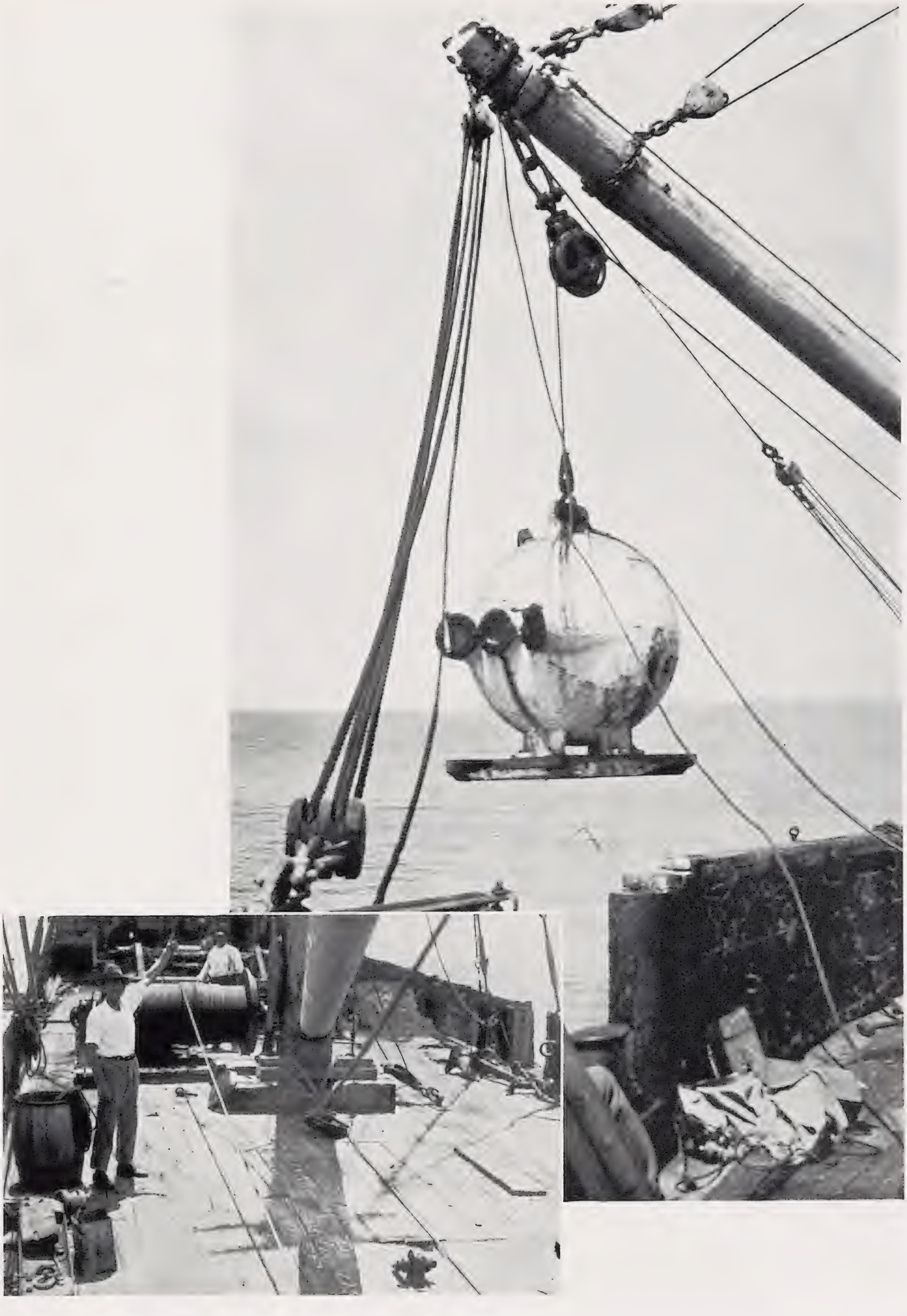
After a few minutes I sent up an order, put out the light and we knew that we were sinking. The twilight (the word had become absurd, but I could coin no other) deepened, but we still spoke of its brilliance. It seemed to me that it must be like the last terrific upflare of a flame before it is quenched. I found we were both expecting at any moment to have it blown out, and to enter a zone of absolute darkness. But

Our Quarter-mile Dive; Shown in Twelve Photographs

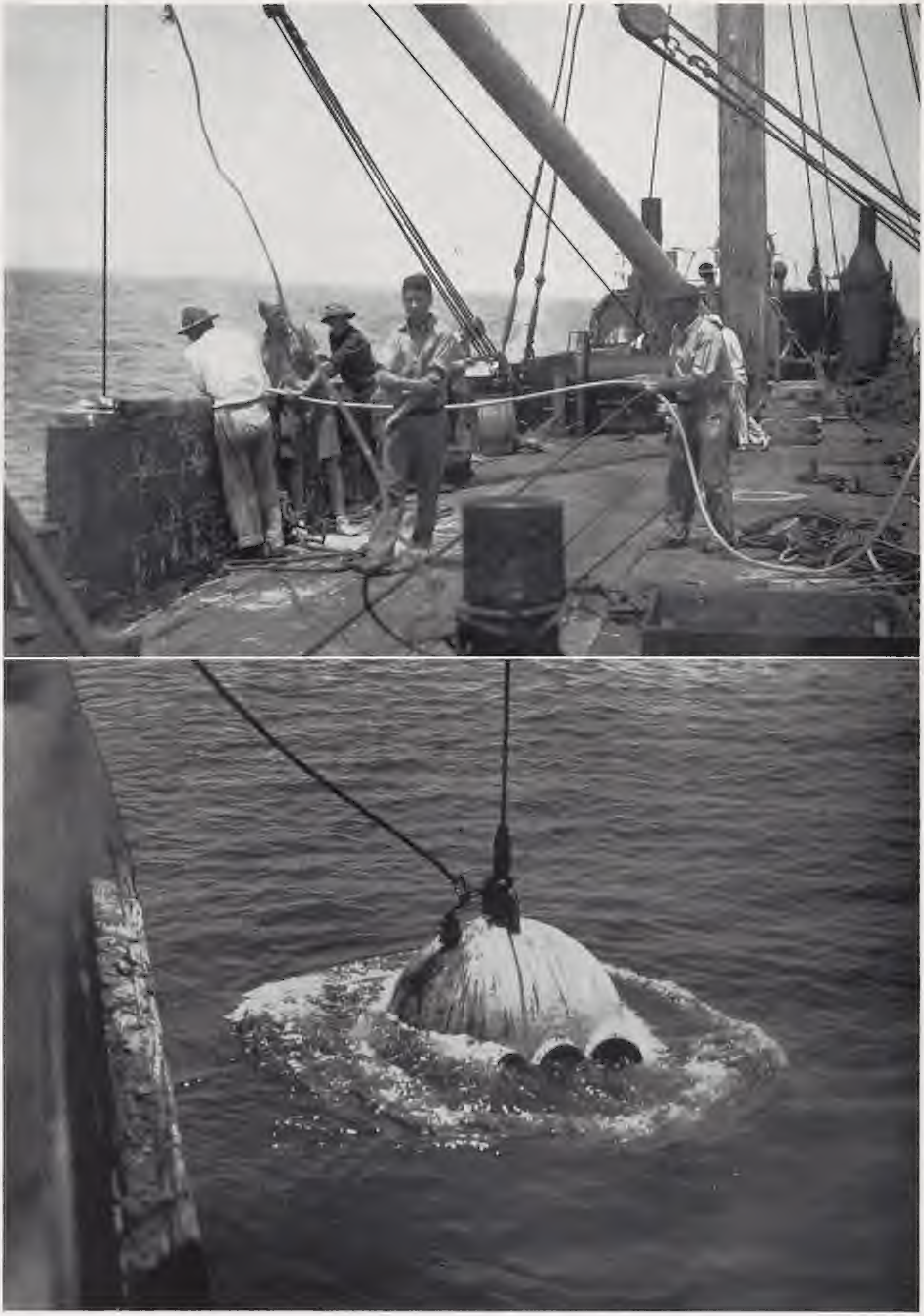
Upper: The *Gladisfen* towing the barge *Ready* out to sea. Photograph by Gloria Hollister. *Lower:* Deck of the *Ready*, showing the powerful lifting yard and the bathysphere. This, and the following photographs by J. Connery.



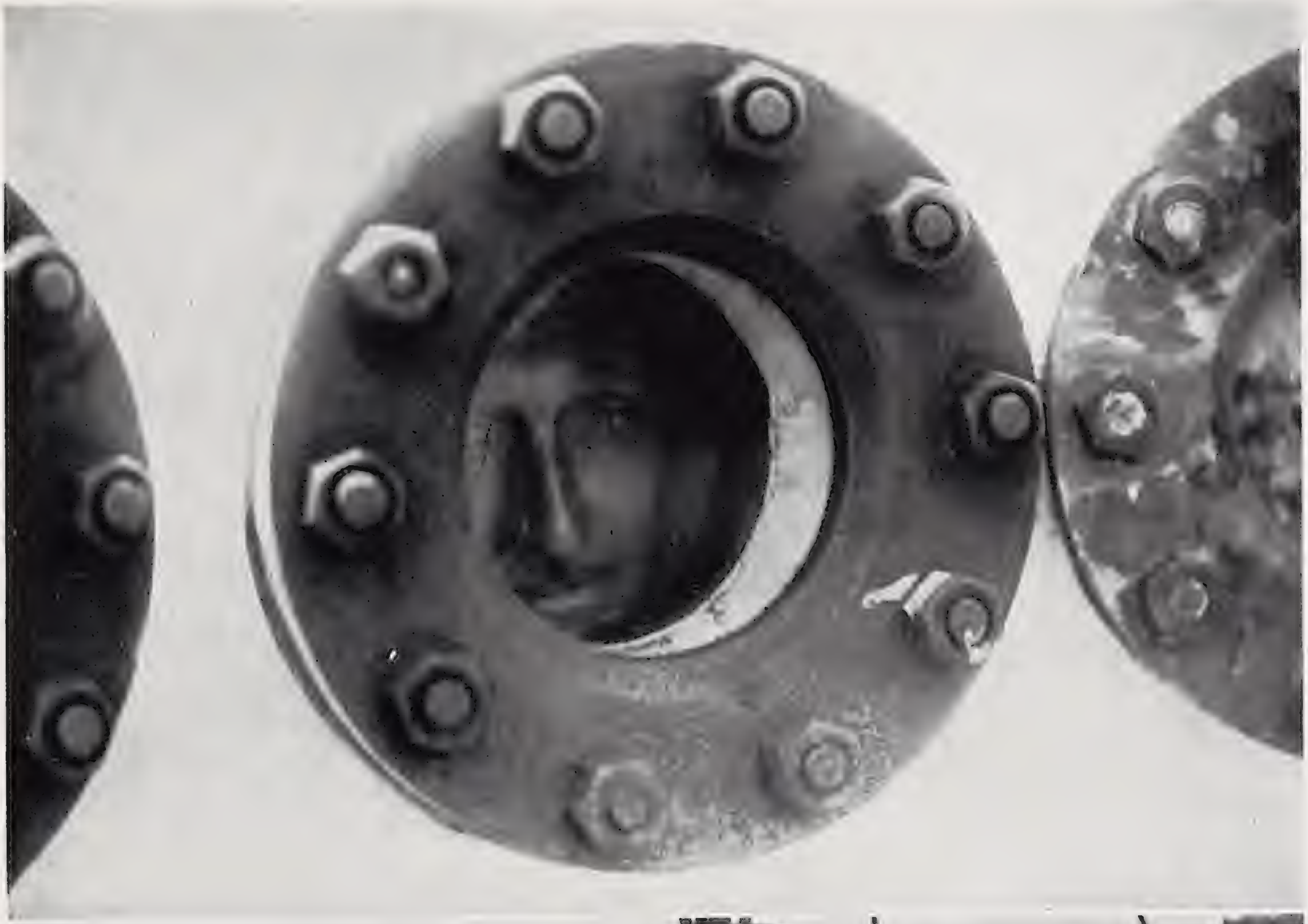
Upper: Deck of the *Ready,* with electric engine. Gloria Hollister taking notes telephoned up from the divers in the bathysphere. *Lower:* Bathysphere ready for the deep descent, with the flags of the Explorers' Club and of the Tropical Research Department of the New York Zoological Society.

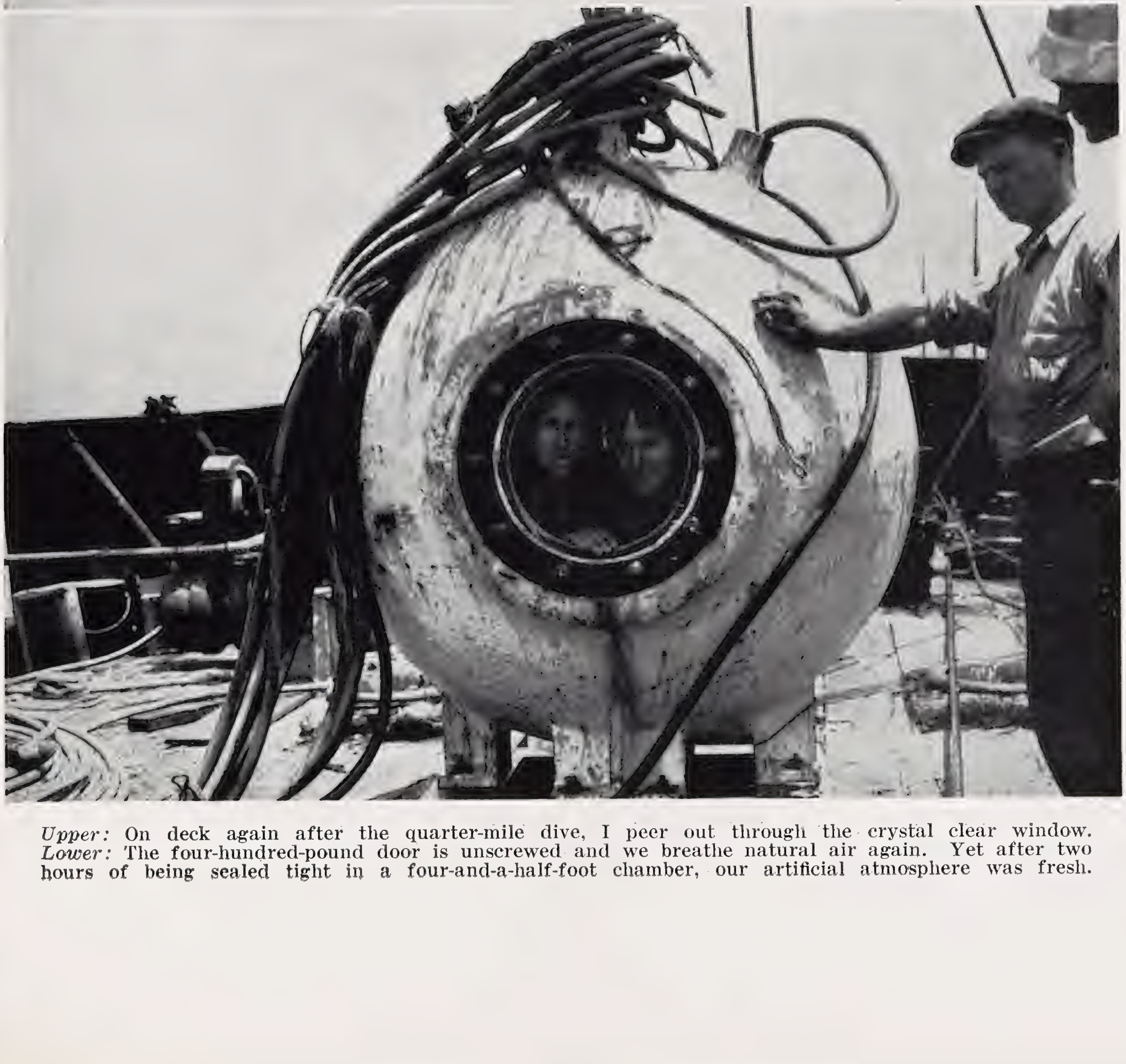


Upper: The bathysphere poised over the water with Beebe and Barton inside, ready for one of the deep sea dives. *Lower:* The *Arcturus* winch and the heavy cable, with John Tee-Van in charge of the deck crew.

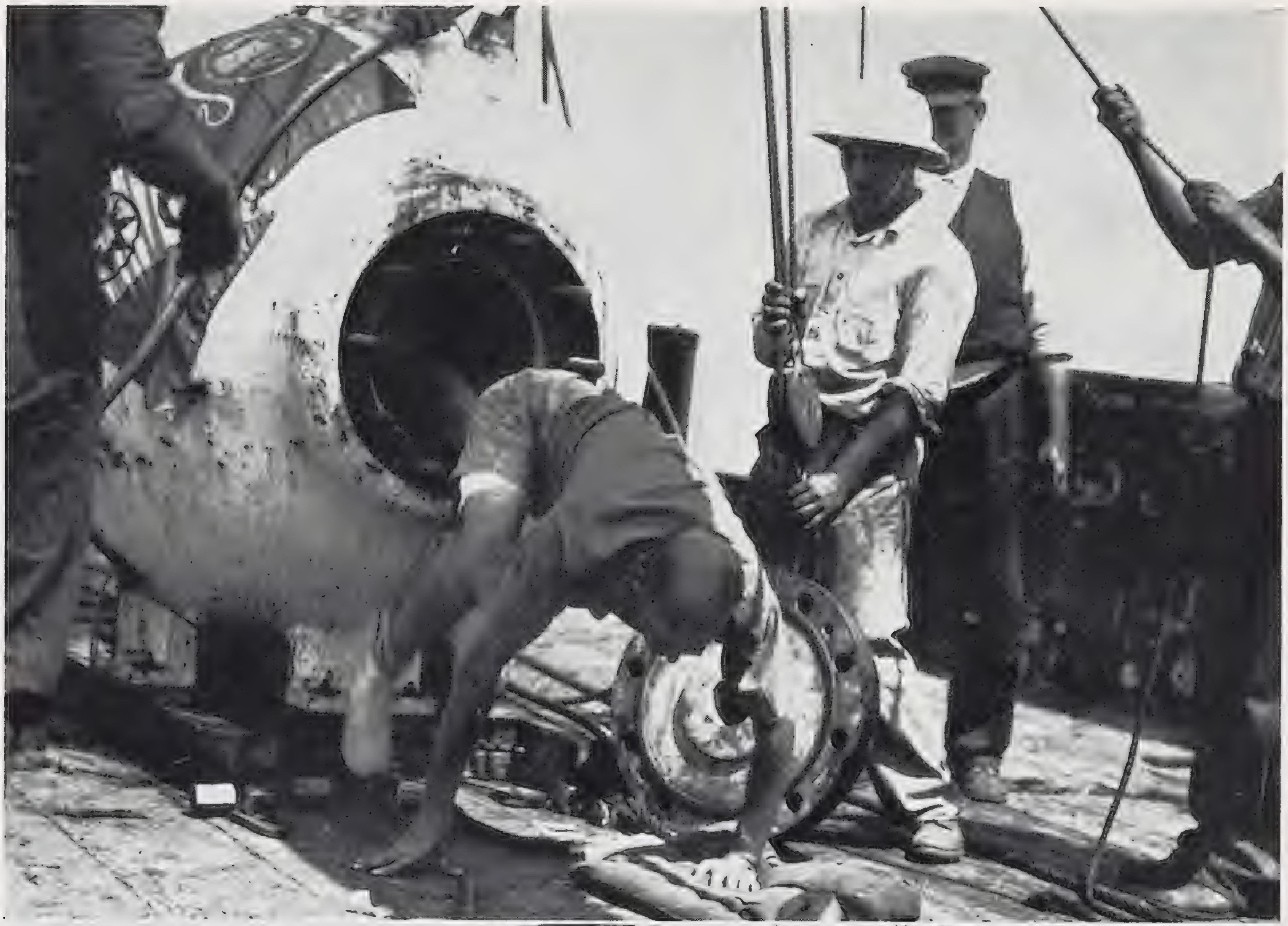


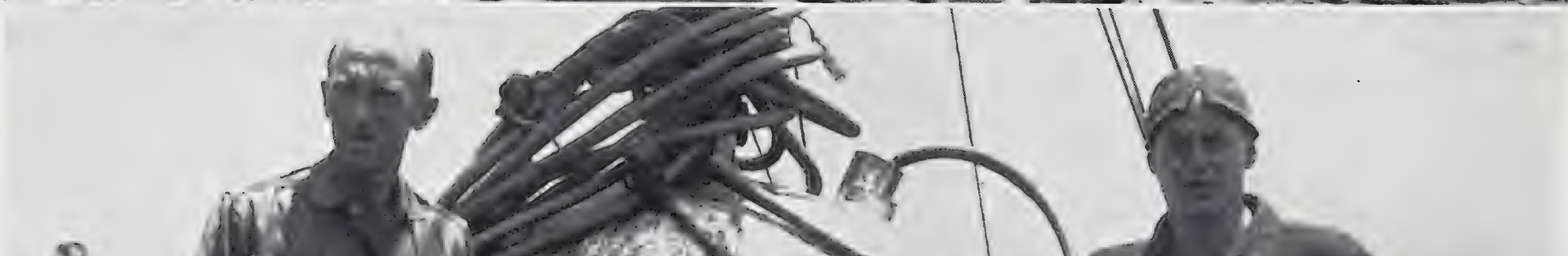
Upper: The bathysphere is on its way up and the cable is being wound in over the winch; the electric hose drawn in by hand. *Lower:* We get our first glimpse of sunshine again as the great steel ball breaks the surface.





Upper: On deck again after the quarter-mile dive, I peer out through the crystal clear window. *Lower:* The four-hundred-pound door is unscrewed and we breathe natural air again. Yet after two hours of being sealed tight in a four-and-a-half-foot chamber, our artificial atmosphere was fresh.





Upper: Our emergence from the bathysphere is somewhat like the progression of seals. We were frightfully stiff from curling up on cold steel for so long a time. *Lower:* We hope another year to go down to a half-mile and remain there for hours.

only by shutting my eyes and opening them again could I realize the terrible *slowness* of the deepening shade. On the earth at night in moonlight, I can always imagine the yellow of sunshine, the scarlet of invisible blossoms, but here, when the searchlight was off, yellow and orange and red were unthinkable. The blue which filled all space admitted no thought of other colors.

We spoke very seldom now. Barton examined the dripping floor, took the temperatures, watched and adjusted the oxygen tank, and now and then asked "What depth now?" "Yes, we're all right." "No, the leak's not increasing." "Its as brilliant as ever."

And we both knew it was not as brilliant as ever, but our eyes kept telling us to say so. It actually seemed to me to have a brilliance and intensity which the sunshine lacked; sunshine, that is, as I remembered it in what seemed ages ago.

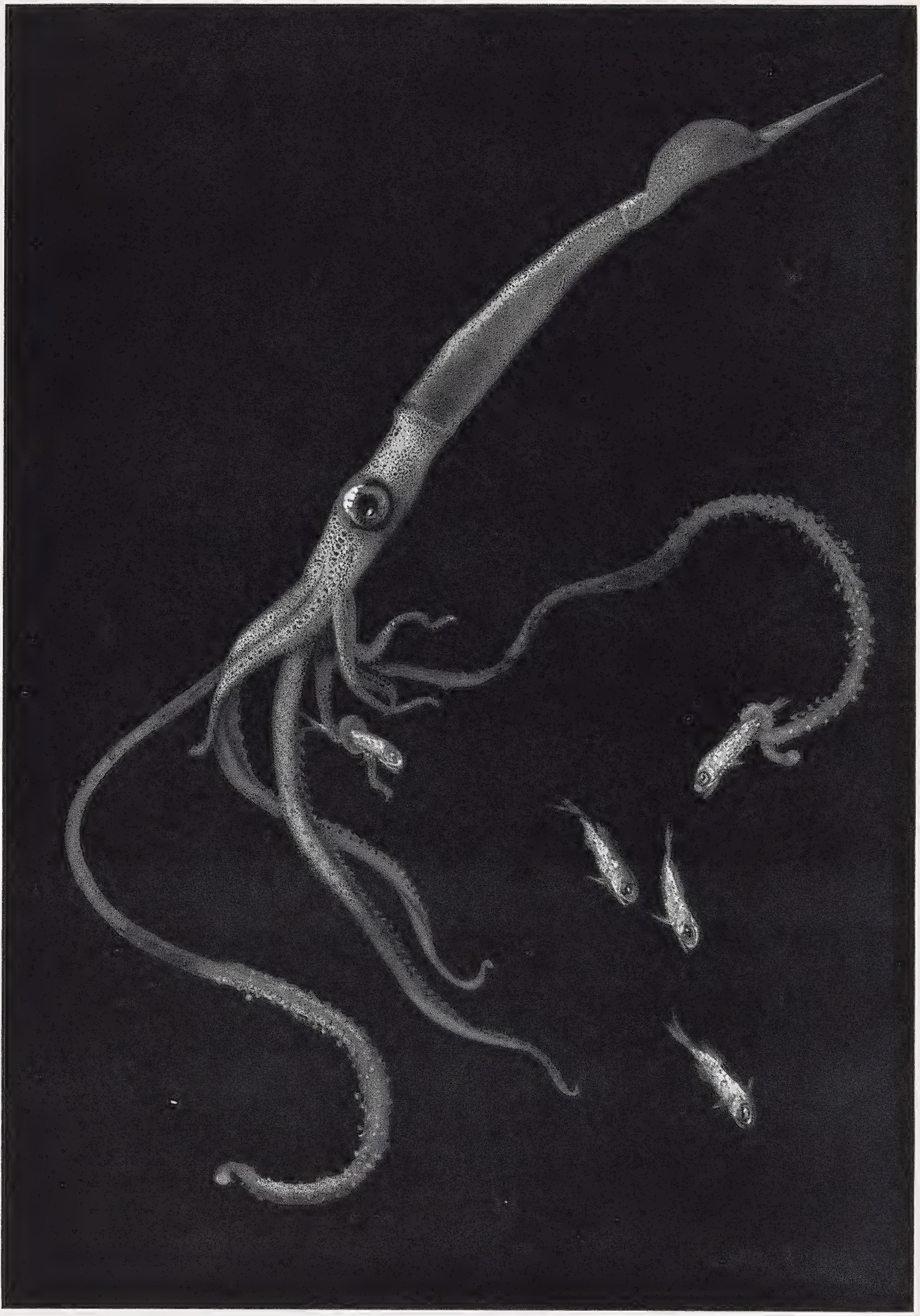
"800 feet" now came down the wire and I called a halt. There seemed no reason why we should not go on to 1000; the leak was no worse, our palm leaf fans kept the oxygen circulating so that we had no sense of stuffiness. Yet some hunch, some mental warning which I have had a half dozen critical times in my life spelled bottom for this trip. This settled, I concentrated on the window for five minutes.

The three exciting internal events which marked this first deep descent were, first the discovery of the slight leak beneath the door at 300 feet, which steadily lessened as we went down: next the accidental wetting and short-circuiting of the electric light switch, with attendant splutterings and showers of sparks, which was soon remedied. The third was absurd for it was only Barton pulling out his palm-leaf fan from between the wall of the sphere and the wire lining of one of the chemical racks. I was wholly absorbed at the time in watching some small fish, when the sudden shrieking rasp in the confines of our tiny cell gave me and the listener at the other end of the telephone wire all the reactions which we might imagine from the simultaneous caving in of both windows and door! After that, out of regard for each other's nerves, we shifted position and carried on our various duties silently.

We reached the deck again just one hour after our start, and sat quietly while the middle bolt was slowly unscrewed. We could hear our compressed air hissing outward through the threads until finally the bolt popped off, and our eardrums vibrated very slightly. After a piece of boiler-factory pounding the big door finally swung off. I started to follow and suddenly realized how the human body could be completely subordinated to the mind. For a full hour I had sat in almost the same position with no thought either of comfort or discomfort, and now I had severally to untwist my feet and legs and bring them to life. As for the cushion, I found it reposing on one of the chemical racks, while I had sat on the hard cold steel in a good-sized puddle of greasy water. I bore the distinct imprint of a monkey wrench for several days. I followed Barton out on deck into the glaring sunshine, whose yellowness can never hereafter be as wonderful as blue can be.

While still upside down, creeping painfully, sealion-wise, over the protruding circle of bolts, I fancied that I heard a strange inexplicable ringing in my ears. When I stood up, I found it was the screeching whistles on the boilers and the deeper toned siren of the *Gladisfen* giving us, all to ourselves, a little celebration in mid-ocean. The wind was right and my staff on Nonsuch ten miles away saw the escaping steam through the telescope binoculars, later heard the sound faintly, and knew that we had made our dive and ascent in safety.

Four days later we were able to put to sea again and sent the bathysphere down to 2000 feet. By the judicious use of white lead we had effectively stopped the leak in the door, and there was no tangle or twist of hose. A tiny flaw which we had watched with suspicion on the outer rim of one of the quartz windows had not increased. The only novelty in the way of unexpected happenings after this two hours' submergence, was that about three feet of the hose had been forced inside the sphere. When this was rectified, Barton and I climbed inside and started enthusiastically for a deeper plunge. Everything went well until at 150 feet we began to experience bad static on the phone. A sentence would come through clearly and then only a mixture of spluttered words. It improved for



An elongated, deep-sea squid, with large, well-developed eyes, and round, orange lights on the tips of the longest arms. It is feeding on a school of lantern fish. Painted by E. M. Bostelmann.

a while, but at 250 feet Barton said "My God! the phone is broken." It was a tragic exclamation, and I felt exactly as he did. The leak on our other trip, the short circuiting, the static today—these were all annoying but not terrifying, and as I have already mentioned, the sound of the human voice had, all unconsciously to us, been a much surer bond than the steel cable or the sturdiness of the sphere. We had neither of us felt before quite the same realization of our position in space as we did now. The silence was oppressive and ominous, and our whispers to each other did nothing to alleviate it. The dark blue outside became cold and inimical. We did our best to signal with the searchlight, knowing that answering flickering must be reflected in the checking bulb on deck. We felt a sudden weight beneath us and knew that we were being reeled swiftly to the surface. A momentary delay came and we knew the single clamp was being removed. Some part of my brain worked steadily on and counted twenty-four jellyfish swimming past, and then we rose swiftly. As soon as the ascent first began my mind went to the people on deck, and I knew that they were getting the worst of this dive. As we shot into the air and over the bulwarks I caught a glimpse of Miss Hollister's face, and that of one of the crew and I knew how little we had appreciated the strain of the last two minutes. I jammed my face as closely as possible to the glass and assumed what I supposed was a reassuring grin, and the second attempt at a deep dive was over. A broken wire had caused the trouble, and eventually we had to cut off and throw away fifty fathoms of the hose.

The next day, June 11, was a perfect one for our work, and we were able to take advantage of it and make our deepest descent, to a depth of 1426 feet, or well over a quarter of a land mile. When we went out in our launch to the *Ready,* we found there had been a fire on board in the night which had taken several hours to put out. The side and part of the aft gunwale had been badly charred, but no serious damage done, while the hose, winch, and sphere had escaped. With our ancient barge looking a little more than usual like a deserted hulk, we put to sea again. As there was a current and an outward set, this time I stopped at a point in the ocean five miles south of Nonsuch, where former soundings had given us a depth of 750 fathoms.

This was Dive Number Seven for the bathysphere, and we climbed in at 9:50 A. M. We had made a number of improvements since the first dive. The inside had been painted black so as not to interfere with observations. Barton had come to look upon his very greasy leather skull-cap as a mascot, so when he could not find it, the central bolt was unscrewed, and the *Ready* searched thoroughly for five minutes, after which he found he was sitting on it. We now had a special place for fans and monkey wrenches and I arranged a shelf for my notebook and pencil, specimens of scarlet crustaceans, and a book with type and plates to test the pseudo-brilliance of the light. The cushion was in its right place, and we had built a shield to shut out the lateral glare from the searchlight. We had also learned to cover the *chevaux-des-frise* of bolts at the entrance with sacking, and so to soften the effects of our frantic wrigglings in and out. The shackle of the cable had been shifted from the central to the posterior hole so that the sphere tipped slightly forward and downward when swinging free. This gave me a better outlook in a slightly oblique downward direction. The hose fastening on the sphere had been tightened so that there was less chance of our being smothered in its entwining coils, which would have been an undramatic, Laocoön ending.

This time we took a chance on everything being in good order, and did not make an experimental submergence. We fastened the flag of the Tropical Research Department of the Zoological Society and that of the Explorer's Club to the bathysphere, and tied a very ancient squid wrapped in cheese-cloth just beneath the observation windows. Dangling in front and just to one side was a cluster of luminous hooks attractively baited. With the searchlight ready to turn on, I felt that I had contrived all the attractions possible for luring deep sea fish within my observational zone.

Barton and I were screwed and bolted in at 10 o'clock, and four minutes later touched water. The surface was crossed with small wavelets, and three times before we were completely submerged the distant Gladisfen and the level horizon were etched clearly on the glass, and as instantly erased by a green and white smother. We sank slowly and I peered upward and watched the under side of the surface rise above me. When the rush of silvery bubble-smoke imprisoned beneath the sphere had passed, the surface showed clear. From the point of view of a submarine creature, I should by rights call it the floor of the air, and not the ceiling of the water. Even when diving in the helmet I am always conscious of the falsity of calling the water wet when I am once immersed in it. Spray blows in one's face and leaves it wet, but down below, the imprisoned air sailing upward, slips through one's fingers like balloon pearls, dry, mobile beauty, leaving only a pleasant sensation.

And now I looked up at our vertical wake of thousands of iridescent swimming bits of air, and, for a moment, forgot whither we were bound.

The boundary of air and water above me appeared perfectly solid, and like a slowly waving, pale green canopy, quilted every where with deep, pale puckers—the sharp apexes of the wavelets above showing as smooth, rounded indentations below. The sunlight sifted down in long, oblique rays as if through some unearthly beautiful cathedral window. The host of motes of dust had their exact counterpart in mid-water, only the general feeling of color was cool green, not yellow. The water was so clear that I could see dimly the distant keel of the Gladisfen, rolling gently. And here and there, like bunches of mistletoe hanging from a chandelier, were clusters of golden Sargassum weed, with only their tips breaking through into the air. A stray berry went past my window and I saw an amusing likeness between its diminutive air-filled sphere and that which was at present my home.

The last thing in focus of the upper world was a long, undulating sea serpent of a rope dangling down from the side of the *Ready*.

We had asked to be lowered slowly. When less than fifty feet beneath the surface I happened to glance at a large deep-sea prawn which I had taken for color experiment. To my astonishment it was no longer scarlet, but a deep velvety black. I opened my copy of "Depths of the Ocean" and the plate of bright red shrimps was as dark as night: No wonder I thought of the light as cool.

A few Aurelia jellyfish drifted past while we were sinking to 50 feet, and at 100 feet a cloud of brown thimble jellies vibrated by the window. These were identical with those which we had observed in vast swarms in Haiti.[1] They are supposed to be surface forms, but here they were pushing against my window twenty fathoms down. They were the first organisms which showed that the fused quartz did away with all distortion. Full twenty feet away I could see them coming, and the knowledge of their actual size—that of a thimble—gave me a gauge of comparison which helped in estimating distance, size and speed of unknown organisms.

I found that little things could change my whole mental outlook in the bathysphere. Up to this moment I had been watching the surface or seeing surface organisms, and I had focused so intensely upward that what was beneath had not yet become vivid. As the last thimble jelly passed, an air bubble broke loose from some hidden corner of the sphere, and writhing from the impetus of its wrenching free, rose swiftly, breaking into three just overhead, and the trio vanished. Now I felt the isolation and the awe which increased with the dimming of the light; the bubble seemed the last link with my upper world, and I wondered whether any of the watchers saw it coming, silver at first, then clothing itself in orange and red iridescense as it reached the surface—to break and merge and be lost forever.

At 200 feet there occurred my first real deep-sea experience on this dive, something which could never be duplicated on the surface of the water. A six-inch fish suddenly appeared, nosed the bag of ancient squid and then took up its position close to the glass of my window, less than a foot away from my face. Something about it seemed familiar, yet it was strange. In size, shape and general pattern it was very like a pilot-fish, *Naucrates ductor.* Twice it swam back to the delectable bait and

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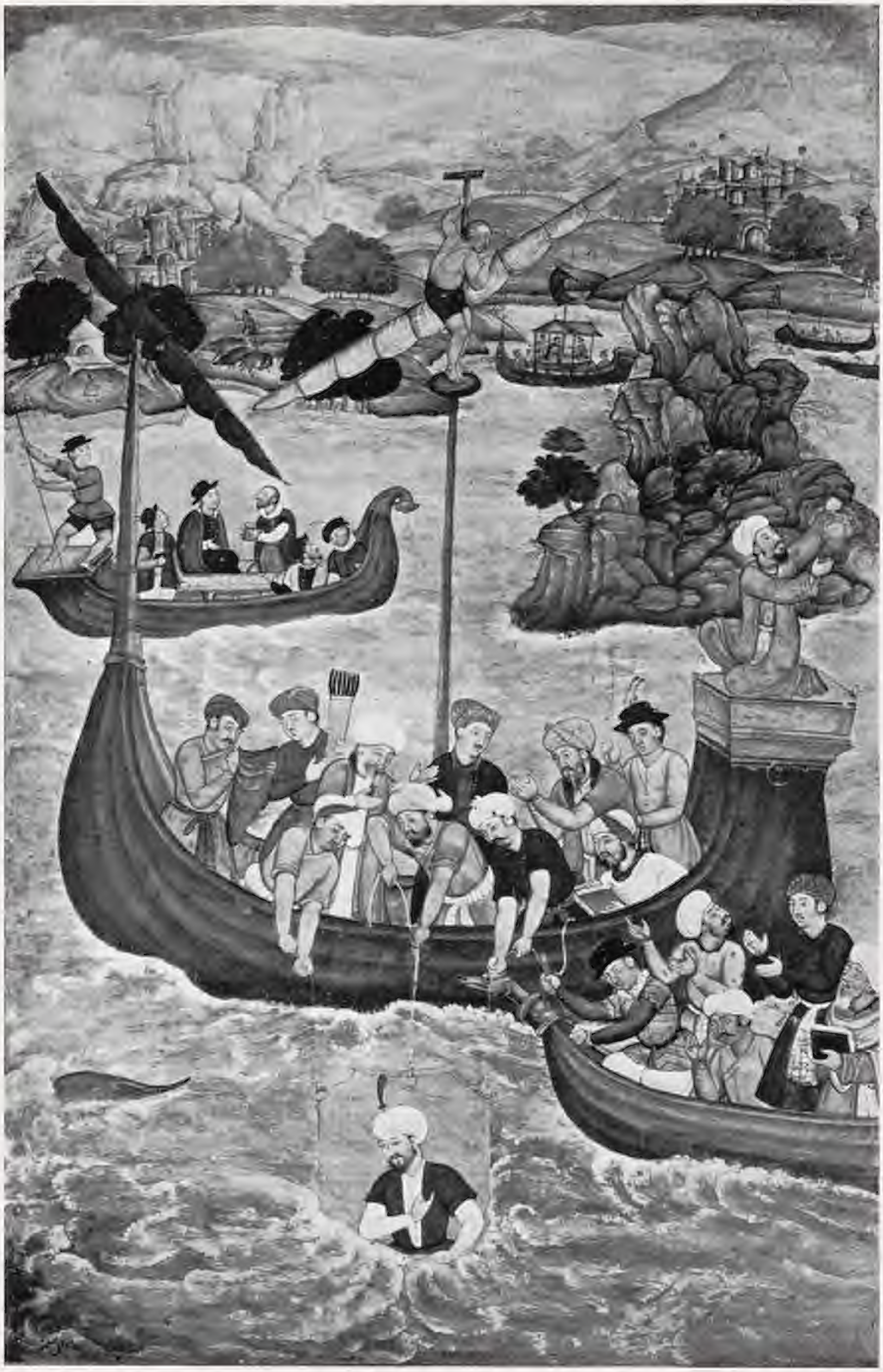
[1] Beneath Tropic Seas, Linuche jellies, pp. 20-23.



Perhaps one of the first dives was made in this glass cylinder depicted by an unknown Indian artist, of the period of Akbar, from an unknown manuscript of about 1575. (Courtesy of the Metropolitan Museum.)

three times returned to where it almost diametered my circular outlook. Then I knew what the trouble was—it was the ghost of a pilot-fish—pure white with eight wide, black, upright bands. At 200 feet a pilot-fish could not be the color he is at the surface, and like Einstein's half-sized world, here was a case where only the faulty, transient memory of man sealed up in a steel sphere had any right to assert that under different conditions the fish would show many colors other than the dark upright bands. I am certain that the fish itself aided this pale appearance, for it has considerable power of color change, but this was very different from the mere expansion and contraction of dermal chromatophares. At 250 feet I saw the pilot-fish going *upward.*

At 400 feet we found that we could just read ordinary print with an effort, and yet to the unfocused eye the illumination seemed very brilliant. I found that the two hours' difference between 10 A.M. and noon, marking the two dives, Numbers 4 and 7, although both were made in full sunlight, resulted in fifty per cent less illumination at 10 A.M., than at noon.

In the next few fathoms I saw schools of prawns and two strings of salpa, both appearing dead white.

At 500 feet a four-inch fish came into view and nosed the baited hook. It was almost transparent, the vertebrae and body organs being plainly visible, the eyes and the food-filled stomach the only opaque parts. Since making the dive I have twice captured this fish, the pinkish, semi-transparent young of the scarlet, big-eyed snapper.

At 550 feet I found the temperature inside the bell was 76°, twelve degrees lower than on deck. Near here a big leptocephalus undulated past, a pale ribbon of transparent gelatine with only the two iridescent eyes to indicate its arrival. As it moved I could see the outline faintly—ten inches long at least, and as it passed close, even the parted jaws with their needle teeth were visible. This was the larva of some great sea eel.

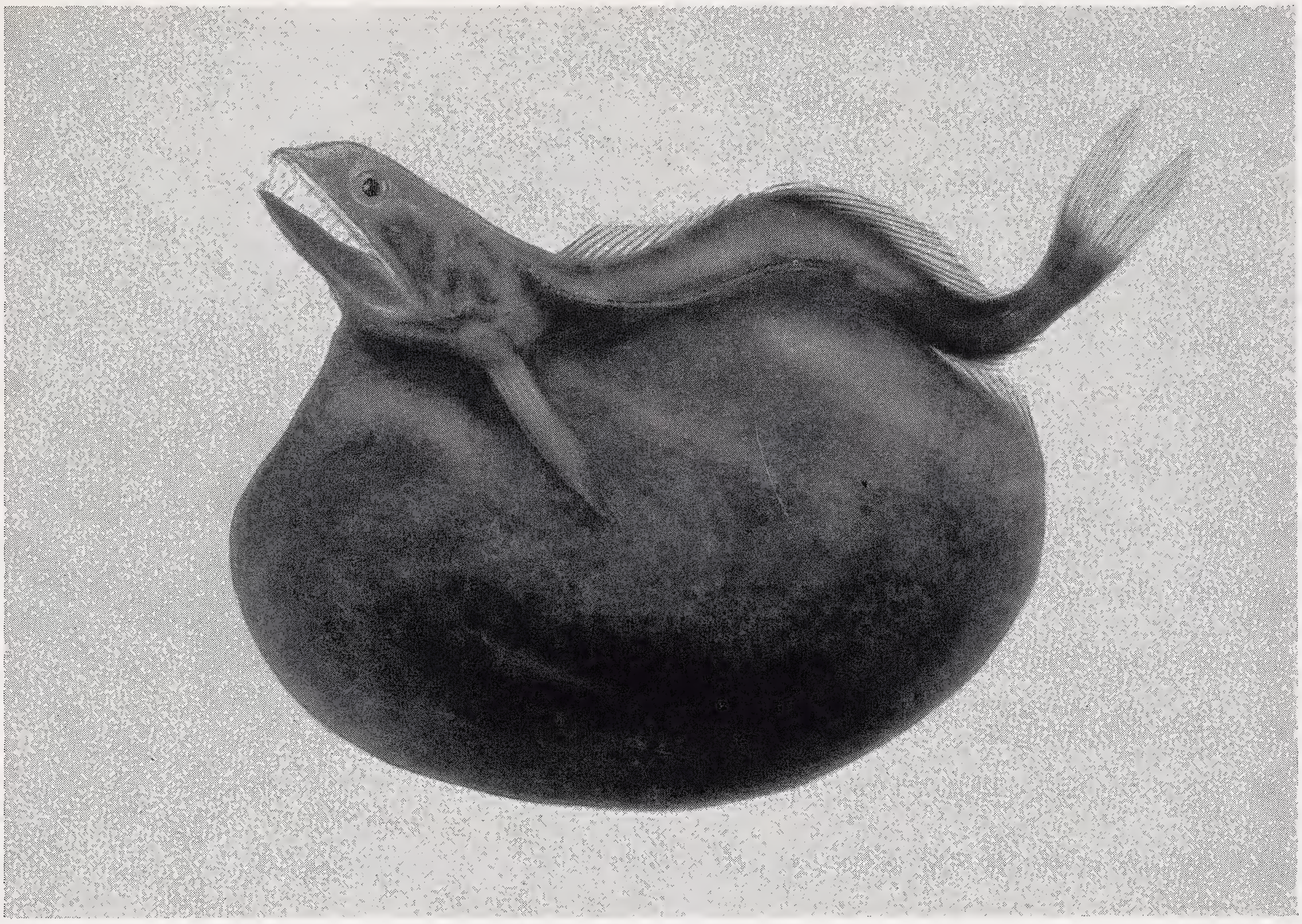
A few fathoms farther and I identified what looked like a host of brown bubbles as little flying snails, *Cavolinia,* which lived within a tissue shell with an outline like a heraldic shield, and which flew through life with a pair of delicate rounded wings. I had seen them alive in the net hauls, but here they were at home in thousands. As they perished from old age or accident or what-not, their shells drifted slowly to the bottom, a mile and a half down, and several times when my net had accidently touched bottom it had brought up quarts of the empty, tinkling shells.

As 600 feet came and passed I saw flashes of light in the distance and at once turned on the search-light, but although the blue outside seemed dark, yet the electric glare had no visible effect, and we turned it off. The sparks of light and the distant flashes kept on from time to time showing the power of these animal illuminations.

650 feet: Several three-inch jellies passed, appearing jet-black.

700 feet: I thought I saw some silver hatchet-fish, heliographing their silver sides, and later observation made this certain, but the glimpse made my eyes hungry for a nearer view. Shrimps and jellies drifted past like flakes of unheard-of storms. We had left the deck at ten o'clock, and twenty-five minutes later we had again reached our record floor—800 feet. This time I had no hunch—reasonable or unreasonable—and three minutes later we were passing through a mist of crustaceans and flapping snails at 900 feet. We both agreed that the light was quite bright enough to read by and then we tried Pica type and found that our eyes showed nothing definite whatever. With the utmost straining I could just distinguish a plate of figures from a page of type. Again the word brilliant slipped wholly free of its usual meaning, and we looked up from our effort to see a real deep-sea eel undulating close to the glass—a slender-jawed *Serrivomer,* bronzy-red as I knew in the dimly-remembered upper world, but here black and white.

At 1000 feet we had a moment's excitement when a loop of black sea-serpenty hose swung around before us, a jet-black line against blackish-blue. Almost at once the sparks we had seen higher up became more abundant and larger. At 1050 feet I saw a series of luminous, coloured dots moving past, similar and yet in-



A deep sea fish *(Chiasmodon niger)* which has swallowed another *(Omosudis)* three times as long as itself. The jaws must be capable of complete dislocation to permit the passage of food of such great size. Photograph by E. M. Bostelmann.

dependent. I turned on the search-light and found it effective at last. At 600 feet it could not be distinguished; here it cut a swath almost material, across my field of vision, and for the first time, as far as I know, in the history of scientific inquiry, the life of these depths was visible. My series of colored lights proved to be a school of silver hatchet-fish, *Argyropelecus,* from a half to two inches in length, all swimming steadily ahead. The marvel of the search-light was that up to its sharp-cut border the blue-blackness revealed nothing but the lights of the fish. In this species these burned steadily, and each showed a colorful swath directed downward—the little iridescent channels of glowing reflections beneath the source of the actual light. These jerked and jogged along until they reached the sharp-edged border-line of the search-light's beam, and as they entered it, every hint of their own illumination disappeared and they showed as spots of shining silver, revealing every detail of fin and eye and utterly absurd outline. The only effect of the yellow rays was to deflect the path of each fish slightly away from their course. Like active little rays of light entering a new medium, the Argeros passed into the search-light at right angles to my eye and left it headed slightly away. With them was a mist of jerking pteropods with their tissuey shields, frisking in and out among the hatchet-fish like a pack of dogs around the mounts.

My hand turned the switch and I looked out into a world of inky blueness where constellations formed and reformed and passed without ceasing. At this moment I heard Gloria Hollister's voice faintly seeping through Barton's head-phone, and it seemed as if the sun-drenched deck of the *Ready* must surely be hundreds of miles away.

I used the searchlight intermittently, and by waiting until I saw some striking illumination I could suddenly turn it on and catch sight of the author before it dashed away.

At 1100 feet we surveyed our sphere carefully. There was no evidence of the hose coming inside, the door was dry as a bone, the oxygen tanks were working well and by occasional use of our palm-leaf fans, the air was kept sweet. The walls of the bathysphere were dripping with moisture, probably sweating from the heat of our bodies condensing on the cold steel. The chemicals were working well, and we had a grand shifting of legs and feet, and settled down for what was ahead of us.

Although I had not been able to see the forms of the illuminated hatchet-fish in the dark, yet a glance out of the window now showed distinctly several, rat-tailed Macrourid-like fish twisting around the bend of the hose. They were distinct, and were wholly new to me. Their profiles were of no Macrourid I had ever seen. As I watched, from the sides of at least two, there flashed six or more bright greenish lights, and the blinding effect on my eyes was such that the fish vanished as if dissolved into water, and the search-light showed not a trace. I have no idea of what they were.

At 1200 feet there dashed into the search-light, without any previous hint of illumination, what I identified as *Idiacanthus,* a long, slender, eel-like form, which twisted and turned about in the glare, excited by some form of emotion. Twice it touched the edge and turned back as if in a hollow cylinder of light. I saw it when at last it left, and I could see no hint of its own light, although it possesses at least three hundred light organs. The great advantage of the electric light was that even transparent fins—as in the present case—reflected a sheen and were momentarily visible.

From this point on I tied a handkerchief about my face just below the eyes, thus shunting my breath downward and keeping the glass clear, and after doing this I realized that not only was I watching with every available rod and cone of both eyes, but I was unconsciously listening at what was going on outside the six-inch circle of quartz.

At 1250 feet several more of the silver hatchets passed, going upward, and prawns became abundant. Between this depth and 1300 feet not a light or an organism was seen: it was fifty feet of terrible emptiness, with the blue mostly of some wholly new color term—a term quite absent from any human language. It was probably sheer imagination but the characteristic most vivid was its transparency. As I looked out I never thought of feet or yards of visibility, but of the hundreds of miles of this color stretching over so much of the world. And with this I will try to leave color alone for a space.

Around 1300 feet life again became evident but wholly luminous. After watching a hundred or more firefly-like flashes I turned on the search-light and saw nothing whatever. These sparks, brilliant though they were, were kindled into conflagration and quenched in the same instant upon invisible bodies. Whatever made them were too small to reach my eyes, as was almost the host of copepods or tiny crustaceans through which we passed now and then. At one time I kept the electric light going for a full minute while we were descending, and I distinctly observed two zones of abundance and a wide interval of very scanty mote-like life. When very close to the glass I could clearly make out the jerking movements of copepods, but they were too small to show anything more. The milky sagitta or arrow worms were more easily detected, the eye catching their swift dart and then focusing on their quiet forms. While still near 1300 feet a group of eight large shrimps passed, showing an indeterminate coloration. We never took large shrimps at this comparatively shallow depth and I do not know what they were.

Barton had just read the thermometer as 72° when I dragged him over to the window to see two more *Argyropelecus* and what I had at last recognized as *Cyclothones.* These are the most abundant of deep-sea fish and we take them in our nets by the thousand. Flickering forms had been bothering me for some time, giving out no light that I could detect, and twisting and wriggling more than any prawn should be able to do. Just as my eyes had at first refused to recognize Pteropods by their right names, I now knew that several times in the last few hundred feet I had seen *Cyclothones.* In the search-light they invariably headed uplight, so that only their thin-lipped mouths and tiny eyes were turned toward me.

Before Barton went back to his instruments, three squids shot into the light, out and in again, changing from black to barred to white as they moved. They showed no luminescence.

At 10:44 we were sitting in absolute silence, our faces reflecting a ghastly bluish sheen. I became conscious of the pulse-throb in my temples and remember that I kept time to it with my fingers on the cold, damp steel of the window ledge. I shifted the handkerchief on my face and carefully wiped the glass, and at this moment we felt the sphere check in its course—we felt ourselves press slightly more heavily on the floor and the telephone said "1400 feet". I had the feeling of a few more meters descent and then we swung quietly at our lowest floor, over a quarter of a mile beneath the surface.

I pressed my face against the glass and looked upward and in the slight segment which I could manage I saw a faint paling of the blue. I peered down and again I felt the old longing to go further, although it looked like the black pit-mouth of hell itself—yet still showed blue. I thought I saw a new fish flapping close to the sphere, but it proved to be the waving edge of the Explorer's Club flag—black as jet at this depth.

My window was clear as crystal, in fact clearer, for fused quartz is one of the most transparent of all substances and transmits all wave-lengths of sunlight. The outside world I now saw through it was, however, a solid, blue-black world, one which seemed born of a single vibration—blue, blue, forever and forever blue.

Once, in a tropical jungle, I had a mighty tree felled. Indians and convicts worked for many days before its downfall was accomplished, and after the cloud of branches, leaves and dust had settled, a small white moth fluttered up from the very heart of the wreckage. As I looked out of my window now I saw a tiny, semi-transparent jelly-fish throbbing slowly past. I had seen numerous jellyfish during my descent and this one aroused only a mental note that this particular species was found at a greater depth then I expected. Barton's voice was droning out something, and when it was repeated I found that he had casually informed me that on every square inch of glass on my window there was a pressure of slightly more than six hundred and fifty pounds. The little moth flying unharmed from the terrific tangle, and the jelly-fish drifting gently past seemed to have something in common. After this I breathed rather more gently in front of my window and wiped the glass with a softer touch, having in mind the nine tons of pressure on its outer surface!

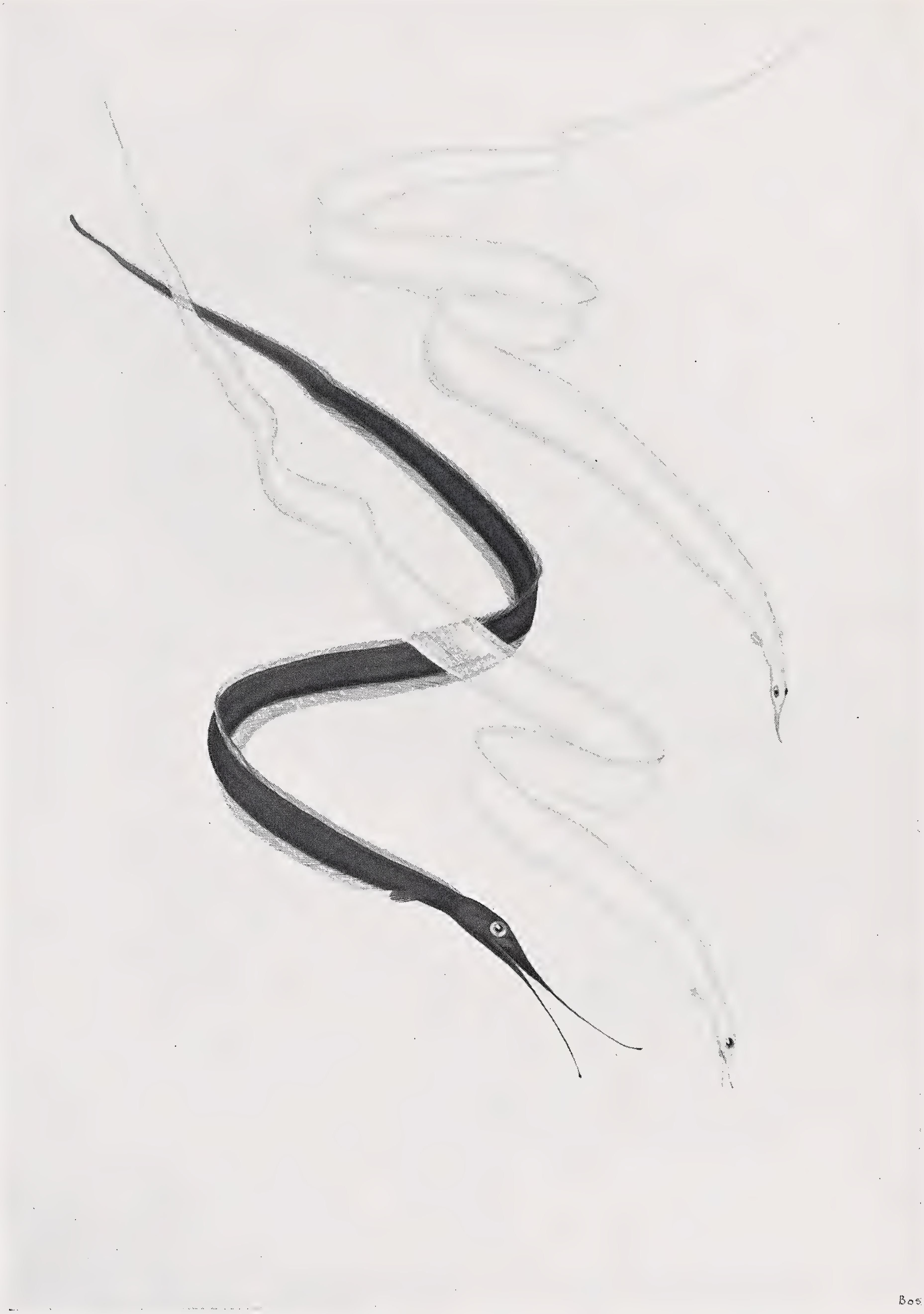
However, it was not until I had ascended that the further information was vouchsafed me that the pressure of the water at our greatest depth, upon the bathysphere from all directions was 6,732,469 pounds, or more concisely, 33,666.2 tons. So far from bringing about an anticlimax of worry, this meant hardly more than the statement that the spiral nebula in Andromeda is 900,000 light years away. Nevertheless I am rather glad that this bit of pregnant information was withheld until I had returned to the surface. If I had known it at the time I think the two-tenths of a ton might have distracted my attention—that 400 pounds being fraught with rather a last-straw-on-the-camel's-back significance.

Like making oneself speak of earthrise instead of sunset, there was nothing but continued mental reassertion which made the pressure believable. A six-inch *Stomias* passed—lights first visible, then three seconds of searchlight for identification, then lights alone—and there seemed no reason why we should not swing the door open and swim out. The baited hooks waved to and fro, and the edge of the Explorer's flag flapped idly and I had to call upon all my imagination to realize that instant, unthinkably instant death would result from the least fracture of glass or collapse of metal. There was no possible chance of being drowned, for the first few drops would have shot through flesh and bone like steel bullets.

The duration of all this rather maudlin comment and unnecessary philosophising occupied possibly ten seconds of the time we spent at 1426 feet.

Although the temperature registered only 72° yet the wall of the sphere was clammy and very cold to the touch and we distinctly felt the chill of this eternally sunless country.

The return trip was made in forty-three minutes, an average of about a foot to a second. Twice during the ascent I was aware of one or more indefinite, large bodies moving about at a distance. On the way down I had accredited



The Avocet-billed Eel *(Nemichthys scolopaceus)*. The adult is dark, the young quite transparent. Painted by E. M. Bostelmann.

this to an over-excited imagination, but after having the experience repeated on several deep dives I am sure that I did see shadowy shapes of large and very real living creatures. What they were I can only guess, and live in hopes of seeing them closer on some future descent.

We stepped out of the bathysphere at 11:52 after a submergence of almost two hours, with good air to breathe, perfect telephonic communication, and the memory of living scenes in a world as strange as that of Mars.

The bathysphere being in perfect shape and the sea remaining calm, I let John Tee-Van and Gloria Hollister go down to a depth of 410 feet where, at the threshhold of the zones of more dangerous pressures, they could realize and have always in memory the sensations which wholly evade description. They were on deck at 1:15 P. M. and we now sent the bathysphere down empty for an extreme test of 2450 feet. On its return to the surface, with the exception of bad twists in the telephone hose, there was no noticeable defect.

Our chief interest on this day of the deepest dive was naturally under sea, but as usual in this area which I have chosen for a three-years' study, there was an abundance of life on and above the surface. Flyingfish of two species were abundant, and while we were drifting and manipulating the bathysphere, Portuguese men-o-war or *Physalia* passed us. A large shark kept about the *Ready* but refrained from our hopeful expectation of allowing himself to be seen through the windows of the sphere. A school of dolphins passed, and at two o'clock a good-sized manta or devilfish flapped slowly, close across our bows, giving abundant opportunity to memorize the exact pattern of black and white. Tropic-birds dipped down to look at us on their way to and from their Bermuda nests and in one spot eight shearwaters fought and screamed and fairly rolled over one another in a most undignified and unavian manner, as they strove for some tough-muscled food, probably a large squid, on the surface. Two immature herring gulls kept at a distance from us as they do from Bermuda all winter.

Although we did not voice it at the time and were usually quite unconscious of it, every descent put a rather severe strain on both the deck staff and ourselves. Now and then this relaxed and we sent back and forth on the telephone somewhat infantile jokes. One of these ended in a surprise. We were at the bottom of an 800 foot level when Gloria Hollister sent down word that a gull was flying about the *Ready*, and a moment later said that it was a young herring gull. I relayed the information that I had made a note of it—qualifying thus as the first ornithologist who had ever made a submarine bird note, and then contradicted it by remembering that when diving in a helmet off Marlborough in the Galapagos I had recorded on my zinc tablet a passing visit from two penguins.

To a question as to what was happening I retorted that two *Ipnops* had taken our hooks—this fish being one that we much desired but had not yet seen or taken. Down came the statement that one of the men had just scooped up a big deep-sea fish with his hands on the surface. I jeered—and then, seeing a luminous fish, snapped into an excited account of what began to come into view. When we returned to the surface I was astonished to discover that the capture of the deep-sea fish was not a rather pointless joke but a fact. In some way a giant specimen of *Myctophum affine* had got mixed up with the sphere or hose, and had come to the surface somewhat damaged. It was the world's record for size.

The following week was too rough to go to sea and not until the eighth day, June 19th, did I think it wise to try another dive. On this day Barton and I made four dives, two in the open sea to a depth of 800 feet, and two over the insular shelf to depths of 120 and 80 feet respectively. All were made with definite objectives and we were successful in every respect.

Dive Number 10 was devoted to constant spectroscopic and intensity records. I made eighteen observations from the surface to 800 feet, and six on the way up, telephoning them direct to Miss Hollister. The accompanying colored plate is as close a reproduction as possible of the diminishing spectrum, from the air to a depth of 800 feet. While, to a trained physicist, it will be recognized as only a replica of a spectrum seen through diminishing light, yet it is of interest as closely representing what my eye recorded beneath the sea.

As we plunged beneath the surface I unlimbered my small Zeiss spectroscope, adjusted the scale to bring the sodium line opposite its proper wave length number, and began to concentrate on the limits of visibility at this topmost level, of the array of colors, spread out in the rainbow-like band of their natural order—red, orange, yellow, green, blue, indigo and violet. The intensity recorder was a cinophot intended for photographic exposure. The detailed records are given beyond, under the systematic observations. There is of course little refinement about these notes, but on the spur of the moment I had to do what I could with the simple instruments at hand. In future descents to greater depths I shall arm myself with more accurate means of record.

Just beneath the surface the red diminished to one-half its normal width. At 20 feet there was only a thread of red, and at 50 feet the orange was dominant. At 100 feet the orange was much narrowed, and had almost vanished at 150. At 200 feet there was no orange, faint yellow and less green than at the surface. At 300 the whole spectrum was dim; the yellow almost gone, with a dirty brown edge toward the red end. The blue was much narrower. At 350 feet I should give as a rough analysis of the spectrum, 50 per cent blue-violet, 25 per cent green, 25 per cent colorless pale light. At 400 feet the violet had completely taken the place of the blue. At 450 no blue remained, only violet and the faintest green, too faint for naming if I had not known what it had been at upper levels. At 700 feet there was no color detectable by either of us.

Finally, at 800 feet the spectrum showed to the eye pale grayish-white, due of course, to the small amount of light passing to any part of my eye through the spectroscope. The brightness was very low and all ability to appraise the hue was gone, so I saw what I can only describe as grayish-white, which was no doubt, wholly subjective. It was a very narrow area, not far from the middle of the spectrum, about the 520th wave line, blurred, fading out slowly toward the violet end, and much more abruptly toward the red end. Yet when I took my eye from the spectroscope and looked out and down, I saw only the deepest, blackest blue imaginable, a color which in the spectrum had vanished four hundred feet above, overlaid and superseded by violet.

In addition to intensity and color observations I made complete notes on the fish and other organisms seen, and an hour after I had reascended safely, I made a second 800-foot descent, with the object of comparing biological notes in almost the same locality at similar depths, with only an hour intervening. This comparison was of vital interest.

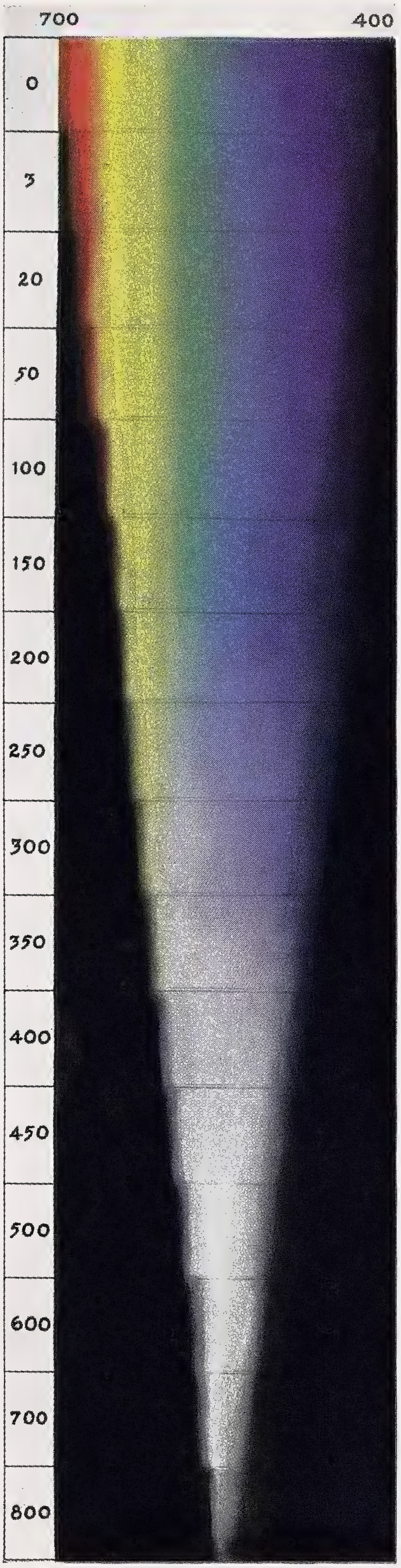
Questions of time and of finances made it imperative that we could carry on only one more day, and rather than try to exceed our depth with apparatus which was showing signs of wear I determined to confine our final efforts to testing out the sphere in an entirely new phase of the work. In the four final dives I did what I might describe as contour diving—to steal an aviation term. I steamed in as close to the shore as I dared, then turned seaward and dived while the *Ready* drifted slowly away from land. As it turned out, the first two dives were probably the most foolhardy things we could have done, for the sphere drifted backward, and from my window I could see only the bottom over which we had passed. If our projecting wooden landing gear had caught in a sudden rise of reef it would have gone very hard with us. As it was, I could only flatten my eyes against the quartz and try and adapt my elevation orders to what the contour promised. Once a crag passed eight feet beneath us and I had a most unpleasant moment while we were rushed up thirty feet.

Early on the following day, June 20th, Barton affixed a double wooden rudder of stationary boards, and during the two final dives we swung around and faced frontward.

I sent the sphere down when the bottom was visible from the deck, and had the lead heaved constantly and telephoned to me, and so rapidly were my orders transmitted to the man at the winch that we rose and fell swiftly by 10 to 30 feet, and so kept the bottom in clear view.

The rapid and radical spectroscopic changes reflected the turbid coastal water as compared with that of the open sea, and at 350 feet the spectrum was very dim, and the violet completely overshadowed the green and the blue.

The thing which impressed me most was the very great size of the fish—snappers, grunts,



Inverted cone of the spectrum as seen by the human eye from the surface to 800 feet. As we descend, there vanish in turn the red, orange, yellow, green, and blue, leaving only the faintest tinge of violet. Finally, to the eye, only a cold, whitish-gray remains in the zone of greatest spectroscopic brightness. Painted by E. M. Bostelmann.

View of the laboratories on Nonsuch, from the tip of South Point, looking west. Photograph by J. Connery.

angelfish, chubs, trumpet-fish, and parrot-fish—all were larger than I have ever seen them when diving in shallower water near shore.

On the shallowest dive—80 feet—I had one of the greatest thrills of the whole undertaking. We were drifting slowly along, lifting over a toothed ridge or settling down into a valley of caves and fissures, when I suddenly saw a black line undulating over the bottom, now in full view, now hidden by a mass of giant sea-plumes, and in an instant I knew I was looking at a deep-sea cable lying quietly on its rocky bed, and I recalled Kipling's words, and I thought of the messages of hope and fear, of joy and death passing along. I shall never send a cable again without recalling something of its path.

We were 300 feet down, with the bottom at least 100 feet beneath, when, without the slightest warning, the green water rained blue parrotfish. They were all deep caerulean blue (*Scarus caeruleus*) almost unmarked, and they varied from about six inches to four feet. Two to three feet was the average, and they dropped obliquely, but very steeply downward, and I counted up to two hundred and then gave up. There must have been several thousand at the very least, and they extended far beyond my vision in every direction. Some were the merest shadow ghosts of parrotfish in the distance, others almost brushed the glass, and the downpour did not cease—we merely passed through it.

Once before, a few miles to the westward, when I descended on a particularly rough day in my helmet to a depth of thirty feet I saw a similar migration or gathering of the blue parrotfish clans. On this occasion they were filled with curiosity about me and milled about for five minutes, fairly blanketing me—almost obliterating the surrounding seascape.

With a calm sea, a steady offshore breeze or current, and our searchlight in working order it will be possible another year to make a systematic survey of the Bermudian insular shelf. Even to repeat the conditions under which we worked would mean perfect facility for recognizing the change in species of fish and such invertebrates as Echinoderms and horny corals; to see and name and note the bottom limits of algae and brain coral and finally to watch for the limits of water-worn and air-worn rocks, and beginnings of the lava flows of old Bermuda Mountain and the wholly unknown transition from the fish of the shore and mid-zones to those of the abysses of ocean.

For over a year, ever since Barton and I had talked about the possibility of descents into the deep sea I had been somewhat pessimistic about any large amount of life we might hope to see from the window. The constant swaying, due to the rolling of the barge high overhead, the great white sphere itself looming up through the blue murk, the apparent scarcity of organisms at best in the depths of the ocean as revealed by all deep sea net hauls, and finally the small size of the aperture, much smaller than one's face—all these seemed handicaps too great to overcome. Yet the hope of such observations was the sole object of the entire project. We never thought of it as a stunt, as beating the record of anyone, as the-first-white-man-who-had-ever, etc.

The slight pessimism I carried with me on the first deep dive made the actual results all the more astonishing. As fish after fish, which heretofore I had seen only in my net hauls and dead, swam into my restricted line of vision, as I saw colors and their absence, activities, modes of swimming, associations which no one had ever had a chance of observing, I felt that all the trouble of planning and achieving were being repaid manyfold. For two years I had been studying the deep-sea fish in a limited area of mid-ocean off Nonsuch, and now when we were at the bottom of our pendulum I realized that I, myself, was down where many hundreds of nets had been hauled. During the coming year I should be able to appreciate the plankton and fish hauls as never before. I felt as an astronomer might who looks through his telescope after having rocketed to Mars and back, or like a palaeontologist who could suddenly annihilate time and see his fossils alive.

In the course of my various dives I found that without the electric search-light for 600 feet in the open ocean, and with its golden swath below that depth, I could distinctly see and recognize—and even accurately identify fish in many cases down to the very species. The most interesting phase of the work was

Main trail from the laboratories to North Beach. The trees are Bermuda cedars, the lesser growth is sagebush or lantana and maritime golden-rod. Photograph by J. Connery.

the optical adjustment to a new angle of view. During the past two years I had looked at a great many thousands of dead *Cyclothones* in the net hauls but it took me three deep dives and possibly twenty observations before I recognized these fish in the rounded objects, opening and closing, which I saw again and again, these being the great mouths of these fish seen from in front.

In my trawling hauls on any two consecutive days over the identical course there is often a very marked difference in the number and character of organims; the first six nets may be rich in species and specimens of fish, the second six with only a few. This is true at times of nets on the same cable—those at 500, 800 and 900 fathoms for example, all with a splendid lot of plankton, large Crustacea, and fish, while the 600 and 700 fathom nets may hold but a scanty showing. On our very first control dive, immediately following one of a similar depth, I saw only a small fraction of the fish which came within the range of the glass on the preceding dive. There seems no doubt that there are zones of richness and of paucity, closely associated, but changing and shifting.

A second unexpected fact was the presence in comparatively shallow levels, of fish which the trawl took only hundreds of fathoms deeper down. I am convinced that this is a result of the light in the upper strata enabling the fish to see the approaching nets and to avoid them. This is a problem wholly apart from the nocturnal migrations upward of many species, which in a number of instances I have been able to verify even on cloudy as compared with sunny days.

The third point is the presence of creatures of larger size than we have ever been able to take in one-metre or two-metre nets, going at two knots.

It is difficult to write of the actual personal experience of descending to such great depths. In my case I was so completely absorbed in conscious observation of what I could see outside my window that only by thinking back and trying to remember what I subconsciously recorded can I consider the adventure as a whole. When in a position of tremendous interest, or at the critical moment at the very climax of a long period of preparation, we often realize the full significance only when it is all over. Fortunately this was not the case in the bathysphere at our 1426 feet of depth. I was curled up in a ball on the cold, damp steel, Barton's voice was droning out questions and assurances, a fan swished back and forth through the air, and the ticking of my watch came as a strange memory sound of another world.

One moment stands out clearly, stimulated by no unusual happening, when not an organism was visible in the water. I sat crouched with my nose and mouth wrapped in a handkerchief and my eyes pressed closely against the cold surface of the tiny circle of quartz—that transparent bit of Mother Earth which held so sturdily its burden of nine tons of water back from my face. There came over me a tremendous wave of emotion, a real appreciation which was momentarily almost superhuman, cosmic, of the whole situation: our barge slowly rolling high overhead in the blazing sunlight like the merest chip in the midst of the ocean, the long thread of cable leading down through the spectrum to our lonely sphere, where, sealed tight, we dangled in mid-water, isolated as a lost planet in outermost space.

Here, under a pressure which, if loosened, in a fraction of a second would make amorphus tissue of a human being, breathing our own homemade atmosphere, sending a few comforting words chasing up and down a string of hose, here I was priviliged to sit and try to crystallize something of value, seeing through inadequate eyes and interpreting by a mind wholly unequal to the task.

These are the only words I can command to answer what has been asked of me so many times, "How did it feel, etc., etc., etc.?" And written down they fail utterly. I have quoted it before and probably shall again, but my feeling was that of Herbert Spencer—"an infinitesimal atom floating in illimitable space." No wonder my sole written contribution to science and literature at the time was "Am writing at a depth of a quarter of a mile. A luminous fish is outside the window."

At any rate, here was I, by grace of the ingenuity and generosity of Otis Barton and from the New York Zoological Society side, of Harrison Williams, Mortimer Schiff, and Ernest Weir. And instead of a swift descent and return and only a silly record to brag of, we were staying minutes and hours in the sphere, comfortably looking out and seeing creatures which had evolved in the blackness of a blue midnight for the past one hundred million years or so, ever since the second day of creation when the oceans were born.

It seems to be the habit with modern explorers to measure the extent of new lands they have traversed in terms of well-known states or countries. I, alas, have nothing but additional water to offer, but here goes: If the water of the oceans which we have made our own for a quarter of a mile depth, was equally distributed over all the dry land of the world, the Americas, Europe, Africa and all the rest would be submerged well over a half mile. Or, if you like this sort of thing, I may add that we have provided the possibility of exploring at first hand 35,000,000 cubic miles of water, and these if laid end to end—but the reader can carry on for himself.

We hope in 1931 to continue work with the bathysphere, using new quartz windows and fresh, electrically wired hose, and if possible we intend to penetrate the ocean a full half-mile, and study the abyssmal life at that depth. But there is sufficient work for a life-time well within the zone of new territory in the open ocean which we have added to human activities.

We have set ourselves four objects for next year:

(1) To descend to 500 or 600 fathoms.

(2) To remain for several hours continually at certain definite depths, for prolonged observation.

(3) To carry out definite tests of light, pressure and temperature with adequate instruments.

(4) To trace the gradual change from shallow water fauna to that of the deep sea.

The importance of the whole adventure may be summed up in a single sentence: The margin of safety, as we have demonstrated, makes future research in this province possible and reasonable; the results, both in sheer accuracy of observation, and abundance and variety of visual material will warrant the continuation of this method of research.

A vast school of three- and four-foot Blue Parrot-fish *(Scarus caeruleus)* swam past the bathysphere when we were near the bottom, a mile off shore.
Painted by E. M. Bostelmann.

The Bathysphere

OTIS BARTON

THE Bathysphere is a spherical steel diving chamber, or tank, as we generally call it. It was designed by the writer, and Messrs. Butler and Barret of Cox and Stevens. It consists of a single casting made by the Watson-Stillman Hydraulic Machinery Company. The first casting weighed five tons, which proved to be too heavy for any of the winches procurable in Bermuda. It was therefore junked. Our present tank weighs five thousand pounds, is four feet nine inches in diameter, and has walls at least an inch and a half thick.

It carries a four hundred pound door, fastened over the man-hole with ten large bolts. This door has a circular metal gasket which fits into a shallow groove. The joint, when packed with a little white lead, was entirely waterproof at twenty-four hundred feet. In the center of the door is a wing bolt plug, which can be screwed in or out quickly.

The windows are cylinders of fused quartz eight inches in diameter and three inches thick. They are a special product of the General Electric Company, the use of fused quartz being suggested by Dr. E. E. Free. They are fitted into cannon-like projections in the front of the tank. The joint is secured with a paper gasket and white lead, and a light steel frame is bolted over each on in front. In all we have had five quartz windows. The first was chipped in an attempt to grind it into its seat. The second gave way under an internal pressure test of one thousand two hundred and fifty pounds to the square inch. It seems probable that the frame in front was bent out, and that the resulting sheering strains broke the glass. The third was broken when the frame bolts were tightened unevenly. The remaining two, however, have never leaked a drop, and have withstood the pressure at twenty-four hundred feet, and will, no doubt, hold much more.

The electric cable was specially made by the Okonite Company. It is one and one-tenth inches in diameter and has a heavy rubber insulation. Inside are two conductors for the lights and two for the telephone. The cable passes through a stuffing box in the top of the tank and is squeezed up by two glands, one on the outside of, and the other within, the sphere. It, too, proved entirely waterproof under all pressures we encountered.

The two big conductors passed to a two hundred and fifty watt spot-light (loaned by E. W. Beggs of the Westinghouse Company) in the right forward projection. We were obliged to seal the left projection with a steel plug, since only two quartz windows were left. At depths of over seven hundred feet the beam of light could be seen passing through the water. When more illumination was desired, it was simply necessary for the divers to direct the deck crew to speed up the generator. The light was turned out by the divers when they wished to observe the effects of the natural submarine illumination. To facilitate these observations the entire interior of the sphere was painted black.

The small conductors passed to the telephone lent by C. R. Moore of the Bell Telephone Laboratory. The two sets were run by a twenty-two and a half volt radio battery on deck. At times static occurred, especially when the free ends on the conductors were disturbed, but on the whole they were a success. All observations taken in the depths were recorded by the deck crew.

The breathing apparatus was designed by Dr. Alvin Barach of New York. On either side clamped to the wall an oxygen tank was carried, either of which would take Dr. Barach's special valve. We set this valve to allow two litres of oxygen per minute to escape for the two divers. One tank lasted about three hours at this rate. Above each tank was a wire mesh tray. One contained soda lime, which took up the CO_2, the other calcium chloride which absorbed the moisture. Palm leaf fans kept air in circulation. During our deepest dive of fourteen hundred feet we were comfortable and cool, although we had been inside more than an hour and a half.

For lowering the bell, we used Dr. William Beebe's seven ton winch and special large reel. To operate these, we installed two boilers on the after part of the long deck of our lighter which had once been the H. M. S. *Ready.* The lighter was in turn towed by the tug *Gladisfen,* of the New York Zoological Society. This equipment was used on the Arcturus Expedition, as were also the three six-ton sheaves. One of these was bolted to the deck about 70 feet in front of the reel at midship. From this the cable returned to the second sheave close to the mainmast and then passed to the third at the end of the heavy boom.

The cable was a special seven-eighths inch, steel-center, non-spinning one made by Roebling. It was thirty-five hundred feet long and would hold twenty-nine tons. It weighed about two tons under water. On our dive of fourteen hundred feet, therefore, the weight of the cable let out was nearly six-sevenths of a ton in the water. To this was added the weight of the bathysphere in water, about seven-eighths of a ton. The amount of cable out was tallied by the special meter wheel also from the Arcturus, as well as by a system of ribbons tied around the cable.

The comparatively light electric cable was let out by hand, and attached at intervals of not more than two hundred feet to the steel one. This we did at first with brass clamps, but later it was found better to tie them together with lengths of rope about a yard in length, since these took up much of the twisting. The winch could be stopped while the tie was made.

Several problems were naturally encountered in these operations. At first we found that the sphere swung badly when raised from the deck. To remedy this we lowered the boom, by means of a second winch, nearly down to the clevis, which connects the cable and sphere. The whole boom was then raised and pulled out over the side, with the top of the tank almost touching the third sheave. From this position the sphere could be lowered upon a single whip.

Perhaps the greatest trouble was caused by the twisting of the rubber hose about the steel cable. Most of this was apparently due to the failure to stretch the latter by letting it all out without the rest of the apparatus and then to rewind it under tension on the reel. When twisting was bad we would tie up the loops every two hundred feet in a loose coil, through the center of which the steel cable continued to operate. Eventually, however, we succeeded in getting out as much as two thousand feet without twisting.

Besides taking observations at greath depths in the open ocean, we tried towing the tank along under the vessel, endeavoring to keep the bottom in sight and not to run into any of the ledges which rise up quite suddenly in these waters. In this work we nailed a wooden rudder on each skid behind, by which the windows were kept always to the front in the direction of motion.

It is with this outfit that we hope next season to study the contours of the bottom down to five hundred feet and also to make dives in the open ocean of two thousand feet.

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How the Bathysphere Was Operated

JOHN TEE-VAN

To operate an elevator in a skyscraper has always been my secret ambition; by a twist of the wrist to shoot rocket-like up and down a shaft, to be guided by the flashes of mysterious colored lights, to converse familiarly with all humanity from charwomen to kings of finance.

This year my elevator ambitions were fulfilled in a most remarkable manner. But instead of being in a prosaic skyscraper I was far out at sea; I controlled the mechanism from outside the lift, and although my passengers stopped at many floors they never alighted. It might indeed have been called a deelevator—for its starting point was at the top and every passenger made the round trip.

This unusual elevator, the bathysphere,[1] is so unique and the results gained from its use have been so valuable, that a description of the method of using the apparatus will not be amiss.

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[1] Information as to sizes and construction of the various parts of the bathysphere, is given mainly in the captions of the diagrams and photographs illustrating this Bulletin.

A typical day's procedure, which will show the operation as well as any other way, can be outlined as follows:

The *Ready,* a hull of an ex-British Navy water-boat, one hundred and thirty feet long and twenty-three feet beam,—with the bathysphere and necessary machinery for operation on board, is towed out to sea by the Zoological Society's chartered tug *Gladisfen.* The days chosen are clear and calm and with little breeze, although on some of the later descents the wind and sea rose to quite an extent. On practically all of the days that the bathysphere was employed, it was necessary, because of current, swell and wind to go from five to eight miles off shore. This was done so that the barge would not drift in toward land in case of accident to any of the machinery, and also to eliminate the possibility of striking an uncharted peak, an unlikely but possible happening in the shallower waters near the coast.

During the journey out steam is raised in the two boilers and the rigging,—cables, fastenings, pulleys, etc., is examined so that by the time that the barge has reached far enough off shore to begin lowering the sphere, everything has been investigated. The quartz windows through which the divers observed are polished and their fastenings checked; the stuffing-box through which the electric light and telephone cable enters the sphere is tightened; the gaskets on the great door are cleaned, the remnants of previously-used white-lead being removed from the groove of the sphere into which the raised gasket of the door fitted. The screw threads of the central bolt of the door receive the same treatment. The ten nuts which hold the door tightly in place are examined and put in numerical order, so that each nut is ready for its own individual bolt. Last but by no means least, attractive, ill-smelling bait is fastened to the sphere just below the quartz windows.

When nearing the desired locality for the descent and just before the divers enter, trays of chemicals are placed on the racks inside the sphere just above the heads of the future occupants,—on one side calcium chloride (anhydrous porous, No. 8 mesh) for absorbing moisture, and on the other side, soda lime (4–8 mesh) for absorbing carbon dioxide. Two tanks of oxygen, each containing eighty gallons of oxygen under a pressure of eighteen hundred pounds, are fastened to the sphere a short distance below the chemical trays, one tank being prepared for immediate use by clamping a valve in place, while the other is held in reserve. These two tanks when filled completely, are sufficient to sustain life in two people for eight hours.

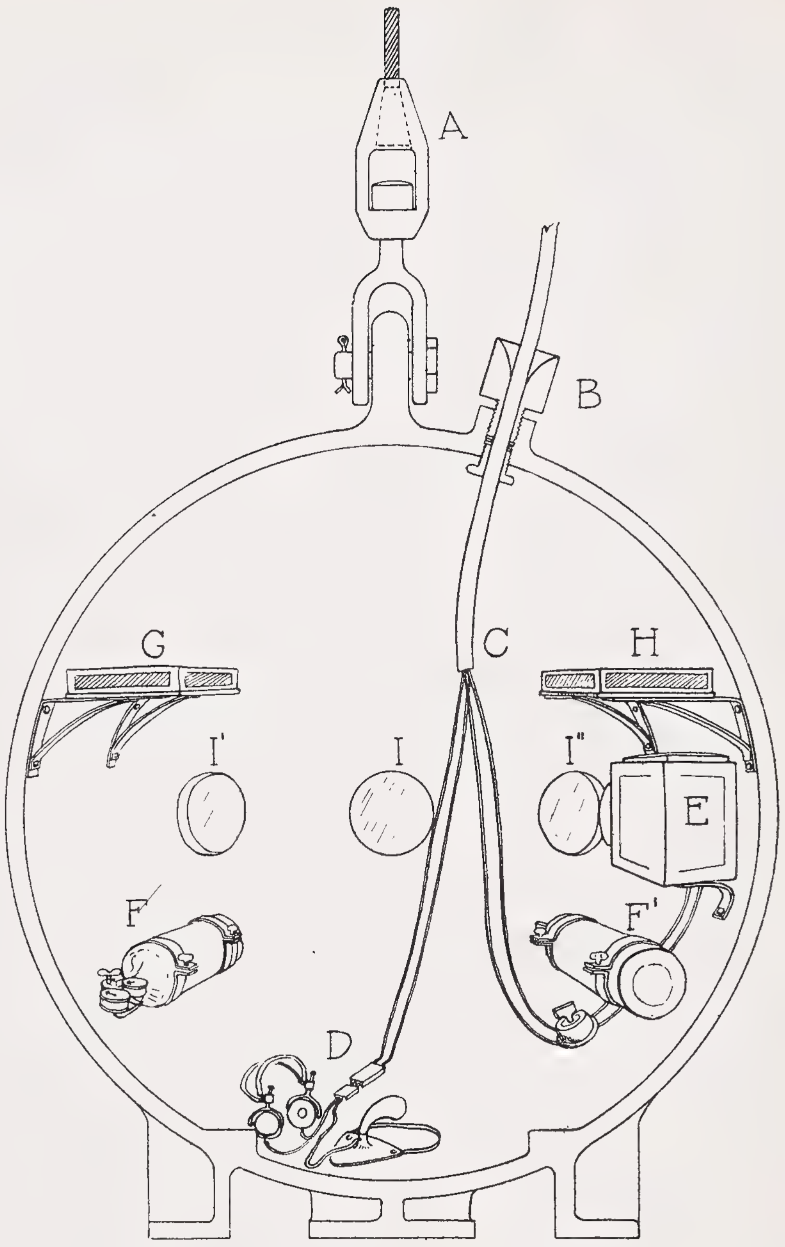
With everything in readiness the ship is hauled up into the wind and swell and the two divers slide through the hatchway into the sphere. Palm-leaf fans to keep the air in circulation, notebooks, tools such as wrenches, screw-drivers, pliers, etc., keys to oxygen valves and most important of all, pillows to cushion the occupants, are passed through the opening. The four-hundred pound door with its central wing-bolt removed, is slung into place, being lifted by means of a small hook screwed temporarily into its upper rim. Lifting the door is accomplished by means of a small block and tackle attached to the boom overhead. When the door is part way in place and its weight supported by the ten bolts, the hook is removed and the door shoved home, the sunken copper washer having been given a light coating of white lead in order to insure absolute sealing. The ten large brass nuts, which had been placed in numerical order on the deck beneath the door are screwed onto their respective bolts as rapidly as possible by hand and tightened by wrenches,—the final tightening being done by hammering the outer ends of the wrenches, a procedure not especially enjoyed by the inmates.

Meanwhile the outer end of the boom has been raised and swung into position so that the sheave is about ten to twelve feet above the sphere,—this distance being sufficient to allow the bathysphere to clear the bulwarks when it is raised and swung over the side.

While the central wing-bolt portion of the door is still open, tests are made of the telephone connections, lights and other apparatus within the sphere. Conversations over the telephone are constantly in progress from now on, and even when there is nothing to communicate, an O.K. is sent out every fifteen or thirty seconds to show that all is well. Everything being reported in proper order, the central bolt with its threads coated with a slight amount of white-lead, is screwed in and hammered tightly into position. As it is tightened, the valve on the oxygen tanks is opened by one of the divers and oxygen allowed to escape into the tank at the rate of two liters per minute.

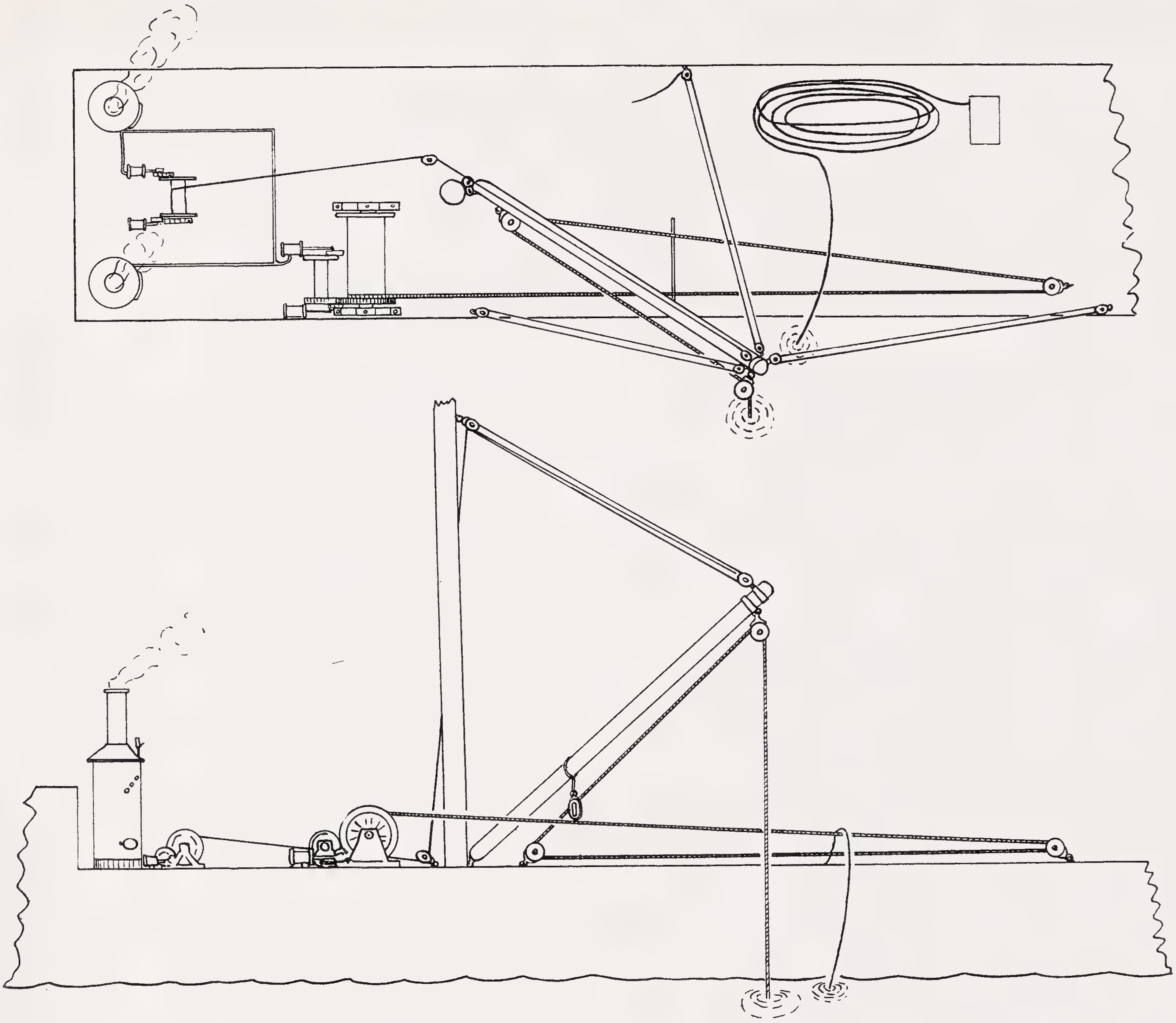
Now everything is ready for the plunge. All hands being stationed at their respective posts, the signal is given to haul the sphere up to the head of the boom, and in a few seconds the ball is suspended over our heads, swinging slightly with the roll of the vessel. All hands fall to and haul or loosen the guys that hold the outer end of the boom in place, one guy each to port, starboard and forward. In a minute or two the order is given to make fast and the sphere is now over the water and ready for submersion. When the proper moment arrives and the barge is rolling but slightly, the bathysphere is lowered into the sea and allowed to descend beneath the surface, its distance from the vessel's side at this moment usually being from ten to fifteen feet.

With the top of the sphere just below the surface, the meter or measuring wheel is set at zero and a piece of white cotton tape is tied to the cable. The meter wheel registered the amount of cable reeled over it directly and all that was necessary was to change this reading from meters to feet. The second method, employing the white tape, functioned as follows: A board indicator was nailed to the deck at fifty feet from the forward sheave. The first tape was tied to the cable at the indicator, and when it had travelled to the sheave and back to the marker again a hundred feet of cable had been let out, and it was only necessary to fasten on another tape to repeat the same performance for the next hundred feet. The measured distance of fifty feet did not include the distance around the pulley, which added two feet to each hundred. The accuracy of these two systems of measurements may be judged by mentioning that the discrepancy between the two amounted to two feet in fourteen hundred and twenty-six.



Section of the Bathysphere, approximately natural size. A, Swivel and Clevis for attaching cable to sphere. The cable was 7-8 inches in diameter and 3500 feet long, with its alternate strands laid in opposite directions to correct the propensity to spin when in the water. The actual attachment of the cable to the swivel was made by separating the strands of the end of the cable until they spread out into a truncated cone, between the interstices of which white metal was poured. This cone was then pulled up into the correspondingly-shaped portion of the swivel. B, Stuffing-box through which the electric cable entered the sphere. Formed of an inner brass gland and an outer stainless steel gland through which the cable ran. Special packing was placed between the outer and inner glands, which were then tightened by means of wrenches. C, Electric cable, 1 and 1-10 inches in diameter and 3000 feet long, heavily insulated and containing two wires for the telephone circuit and two for the electric lights. D, Telephone. E, Searchlight with beam focussed through window I′. F, Oxygen tank ready for use with valve attached—one dial showed the amount of oxygen remaining in the tank, the other the rate of discharge. F′, Reserve Oxygen tank. G, Tray containing soda lime for absorbing carbon dioxide. H, Tray containing calcium chloride for absorbing moisture. I, Main observation window, 6 inches in diameter. The windows were discs of fused quartz 3 inches thick and 8 inches in diameter. I′ and I″, Windows for searchlights. During the 1929 descents window I′ was filled with a steel plate.

The sphere is lowered until it is well below the keel of the barge, and the guys are hauled in until the main cable is but a foot or so from the side of the vessel; it being necessary to have the cable as close as this so that the cable clamps connecting the electric line and the main



Plan and Elevation of the Bathysphere Apparatus as it was arranged on board the *Ready*. Two steam boilers, generating 110 pounds steam pressure, were used to drive the winches. The left hand winch was used for operating the lift which raised or lowered the boom, while the right hand winch carried the main cable which supported the bathysphere. The path of the cable is shown as it passes first from the winch to the sheave near the bow of the barge, thence to a pulley near the mast and fastened to the deck before it finally passes over the sheave at the tip of the boom from which it drops into the sea. On the lower illustration the meter wheel can be seen attached to the boom. The upper illustration shows the various guys that held the upper end of the boom in place and the measuring stick placed fifty feet from the forward sheave. In the upper right hand corner is the generator, attached to the 3000 foot length of electric cable, which when not overboard was coiled on deck on the port side of the vessel. The deck telephone was connected to the main cable at the generator.

cable can be attached. Word is now sent to the divers that the deck crew are waiting upon their orders and from here on all raising and lowering is controlled through the telephones by the occupants of the sphere.

As far as the deck crew is concerned all are at their respective posts. The helmsman maintains a course that eliminates as much rolling as possible, as the ship has just enough forward motion to hold it head to wind and sea. Two men are assigned to fastening on the clamps which attach the electric light and telephone cable to the steel supporting cable. Five others pass this cable from where it is coiled on the port side of the deck, over the main cable and the bulwarks and pay it out at nearly the same rate of speed as the sphere descends. A winchman stands by at the levers of the main winch, while the second winchman who is needed only during the landing period, takes care of the steam boilers. Two of the staff read the meter wheel and keep track of the registration of the amount of cable let out, calling out at each fifty or one hundred-foot interval, while two others of the Nonsuch staff control the telephones and constantly record times, observations, etc.

Orders from below are called out, "Lower fifty feet." With a rumble, the great winch unreels the cable until the first tape reaches the sheave at the bow, when the engine is stopped and word is sent down that, "You are now at fifty feet." The same process continues as the sphere goes lower, a stop being made at each hundred feet to fasten a tape and at every two hundred feet to clamp the electric cable to the main cable.

The electric cable is paid out by hand, its own weight being sufficient to cause slightly more than two hundred feet of itself to run out for each similar unit of supporting cable, thus producing a small amount of slack. This slack is of considerable value in taking care of the twisting of the cable,—a subject discussed later on.

When the sphere reaches approximately one hundred and thirty feet, it passes out of sight of those on board the barge and contact changes from visual and aural to aural only. Lowering continues in the same way, the divers being moved to whatever level they desire, remaining there until their observations are completed.

In bringing the sphere back to the surface, most of the operations employed in lowering are reversed. The electric cable is hauled in by hand, a rather tiresome procedure, but not a very difficult one as the two hundred foot lengths between supporting clamps can easily be hauled upward by two men working side by side. The main cable, however, in ascending, has to be spooled onto the drum, a procedure requiring three men. A snatch block is fastened about the cable and connected to either side of the ship by means of blocks and tackle, thus allowing the cable to be hauled from one side to the other depending upon which side of the drum the cable is being wound upon.

When the sphere on its upward journey, reaches fifty feet from the surface, the boom is once again swung outward so that the bathysphere can pass the side of the ship in safety. When this is accomplished the sphere is brought up so that its top is at the surface of the sea. The actual emergence from water to air is always a gradual one, principally because of the difference in weight of the sphere while in water and in air,—the weight in the former element being about seven-eighths of a ton and in the latter two and a fifth tons. Too swift a motion might produce a sudden strain upon some portion of the machinery.

When the ship is rolling least, the bathysphere is hauled up to the tip of the boom, as close to the sheave as possible. The boom is pulled in until it rests over the mid-line of the ship, and, by means of the second smaller winch, slowly lowered until the sphere once more rests upon the deck. It is necessary to use this method of landing, for if any length of cable is allowed to remain between the sphere and the sheave, the sphere operates as a gigantic pendulum and thrashes violently about.

With the sphere once more on the deck, the central bolt of the door is removed, the ten nuts unscrewed and the great door hoisted out of place. The divers slide out and stretch their cramped limbs and a descent into another world in a unique elevator has been accomplished.

Observing the bottom close inshore in depths down to three hundred and fifty feet required the same operation of the sphere, with the exception that the units of raising and lowering were smaller, ten feet being the usual amount of cable let out at a time, and that extremely close attention had to be paid to rapid manipulation of the winches in case the sphere came suddenly too close to the bottom. When observing the bottom at these depths, the vessel was taken close to the coast and pulled slowly out from shore, the sphere being lowered as the bottom became deeper. In order to keep the sphere from spinning as the ship moved forward, wooden rudders were fastened onto the rear ends of the skids. These effectively kept the windows to the front. Soundings were made every few minutes with a lead line, when the bathysphere was employed in contouring.

As already mentioned, most of the details of the bathysphere are given with the illustrations. A few phases of the outfit and operations which cannot be illustrated in that manner are described here.

On the earlier test descents with the empty sphere, the electric cable came to the surface wound many times about the steel supporting cable, at one time as many as forty-five turns being found in 2,000 feet. Evidently twists insinuate themselves as the steel supporting-cable is wound from its factory reel onto the winch, and these in turn cause the electric line to wind itself up. A single descent of the non-twisting steel cable, with its attendant unwinding, allowed the cable to take its correct lay, and in use after that only a single or at most two turns were to be found in each two hundred feet. During these descents the electric cable was fastened by double-jawed clamps direct to the supporting cable. Afterward it was found better to insert about a yard or so of rope between the cable attachment and the electric cable attachment. Twists, if present, were taken up by the rope, and this if necessary could easily be cut and the clamps removed without trouble.

In the earlier test descents whenever the electric line was twisted about the cable, the turns, as they arrived at the surface, were tied together in large loops, through which the main cable ran. This procedure operated efficiently and required but little effort or time. After the bathysphere arrived on board ship, the coils were unwound by removing the end of the cable from where it entered the sphere and uncoiling it.

The generator employed for electric lighting purposes, was a 110-volt Kohler plant of 1500 watt capacity, connected through 3,000 feet of insulated cable to the sphere. The distance between the generator and the bathysphere caused a drop in the voltage, so that it was necessary to use especially made 90 volt lamps. The electric cable was coiled on deck near the generator when not overboard.

Whenever the divers required electric light they asked for it and the generator was started. The electric light circuit also served as an auxiliary signalling apparatus, as, in case of breakdown of the telephone lines, signals could be sent by turning the electric light off and on by means of switches, situated one in the bathysphere and one at the generator. A control lamp was placed in the circuit so that those on deck could tell when the light was on below.

The telephones were of ordinary type and operated on 16 or 22 volt dry batteries. The instruments were furnished with head phones and neck clips so that the hands of the liaison officer and diver were free at all times.

The crew necessary for the operation of the Bathysphere consisted of the following:

2 divers
1 deck officer in charge of operations on deck, such as control of the winches, raising, lowering, etc.
1 liaison officer, relaying communications between the divers and deck officer, and communicating the observations of the divers to the recorder.
1 recorder, keeping account of time, and noting all observations called through the telephone to the liaison officer from below.
2 winchmen, one on duty at the main winch which controlled the main cable; another who operated a smaller winch which lowered and raised the boom supporting the bathysphere. The second winchman acted as a fireman during the periods in which he was not needed for the winch.
1 steersman, controlling the rudder of the *Ready*.
2 men, clamping the telephone line to the main cable.
9 deckhands, paying out and hauling in telephone cable, hauling guys, winding cable on drum, etc.
1 or 2 messengers, communicating between liaison and deck officers; one of these attended to the generator and its requirements.
1 man, reading meter wheel and tying tapes onto the cable at every hundred feet.

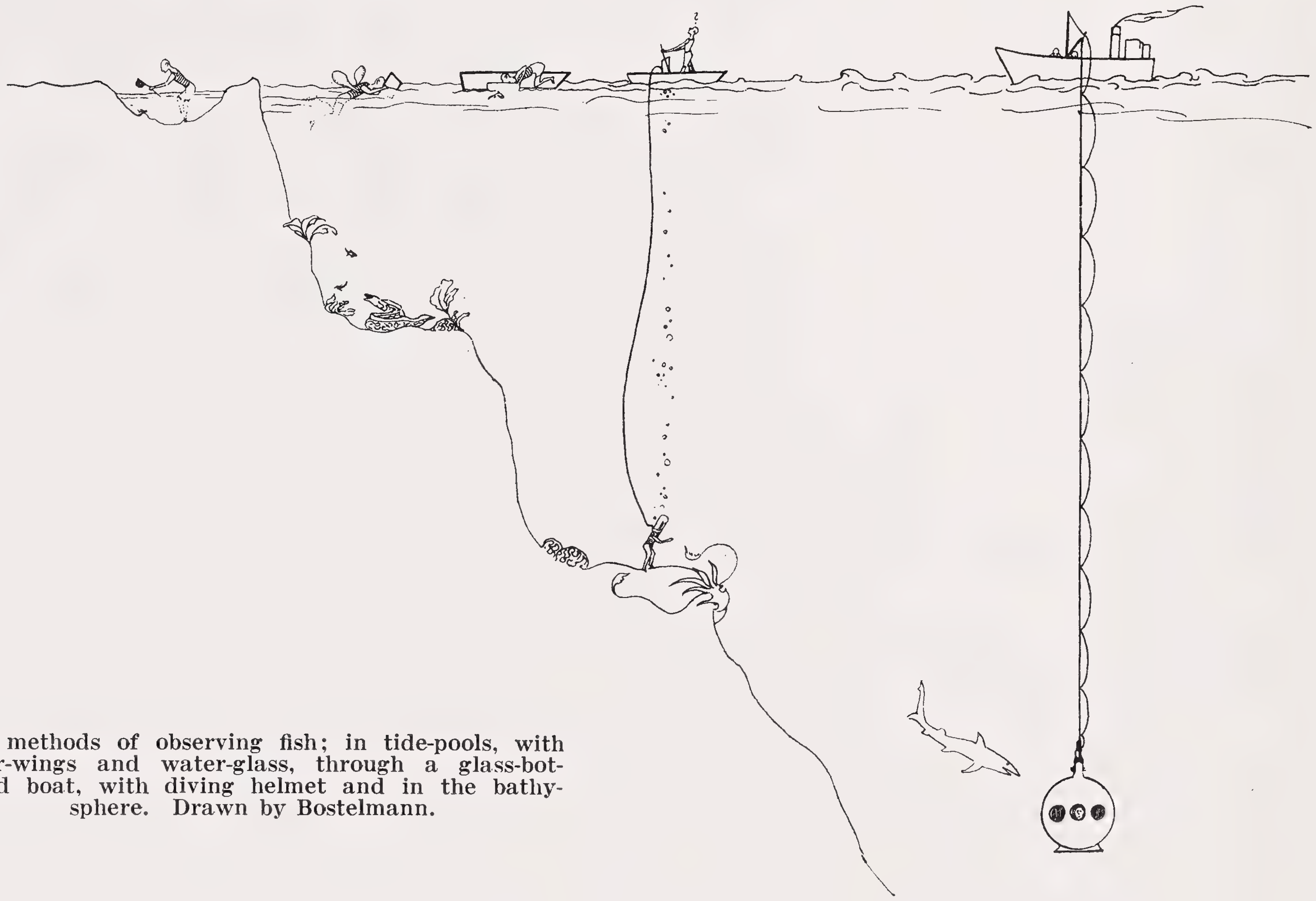
In shallow water when there was a possibility of striking bottom, two men were assigned to sounding, determinations of the depth being made with a lead line every few minutes.

To complete the roster of those necessary for the operation of the sphere, there must be added the crew of the *Gladisfen*, 5 men, and one man who operated the motor-boat which stood by in case of emergency.

Counting the six men last mentioned, it will be seen that the total number needed for lowering the bathysphere amounted to twenty-eight persons including the two divers. This number might have been reduced slightly, but the uniqueness of the venture required an over-complemented crew rather than an under-manned one.

In the use of the bathysphere and its accessory equipment the factors of safety employed ought to be stressed. Those used in the outfit were as great as could be consistently obtained. As an example, the main cable had a breaking strain of twenty-nine tons and a maximum load of three tons.

Safety in the operation of their elevators is the only reason why our skyscrapers are able to exist, and the operation of the bathysphere or deelevator represents a new safe invasion of man, not upward into offices and homes far above the streets and avenues, but downward into the darker deeps where for untold centuries the lights of deep-sea fish have turned on and off in much the same way as the great advertising signs on the roofs of our tall buildings.



Five methods of observing fish; in tide-pools, with water-wings and water-glass, through a glass-bottomed boat, with diving helmet and in the bathysphere. Drawn by Bostelmann.

Telephoning to Davy Jones's Locker

GLORIA HOLLISTER

I WISH my readers could ask Central for Bathysphere 0001 and hear for themselves, as I have, the excited voices and thrilling observations of two pioneer explorers sealed in a sphere of steel, sinking down and down into no-man's-deep.

At ten o'clock on June eleventh I was seated on the rolling foredeck of a weather-worn barge, the *Ready,* in tow of the *Gladisfen* eight miles out at sea south of Nonsuch Island. I was crouched close to the gasoline engine which generated light for the sphere and was adjusting the ear-phones to my head and connecting the telephone battery which was the heart of our only communication with the bathysphere.

The divers were already in the sphere and Dr. Beebe's face appeared at the center window signalling that they were ready for the final electric light and telephone test. I plugged in for only an instant because the hammering on the bolts of the four hundred pound door reverberated over the wire beyond endurance.

There was tense but silent excitement everywhere on deck as each man performed his share of the preparations and then waited at his post for the auspicious calm during which the bathysphere could be swung from deck to water. My brief words of assurance to the divers that everything was ready and in order seemed to echo from every part of the barge. As the sphere was hoisted high above the deck and lowered below the surface, Otis Barton, who had the other end of the telephone, thought and wondered aloud about the many mechanical things that might go wrong. In his excitement he had forgotten that even a faint whisper reverberated in my ears like rushing wind through a gorge. Each suggestion reacted vividly on my keyed-up imagination. I clamped the phones closer to my ears lest these ideas should be overheard and interpreted as demoralizing facts. Soon after the sphere started its descent, reports of almost unbelievable observations came as rapidly as I could record the depth, time and message. This in itself assured me that conditions with the divers were splendid and I frequently called out a message to cheer the anxious staff and crew.

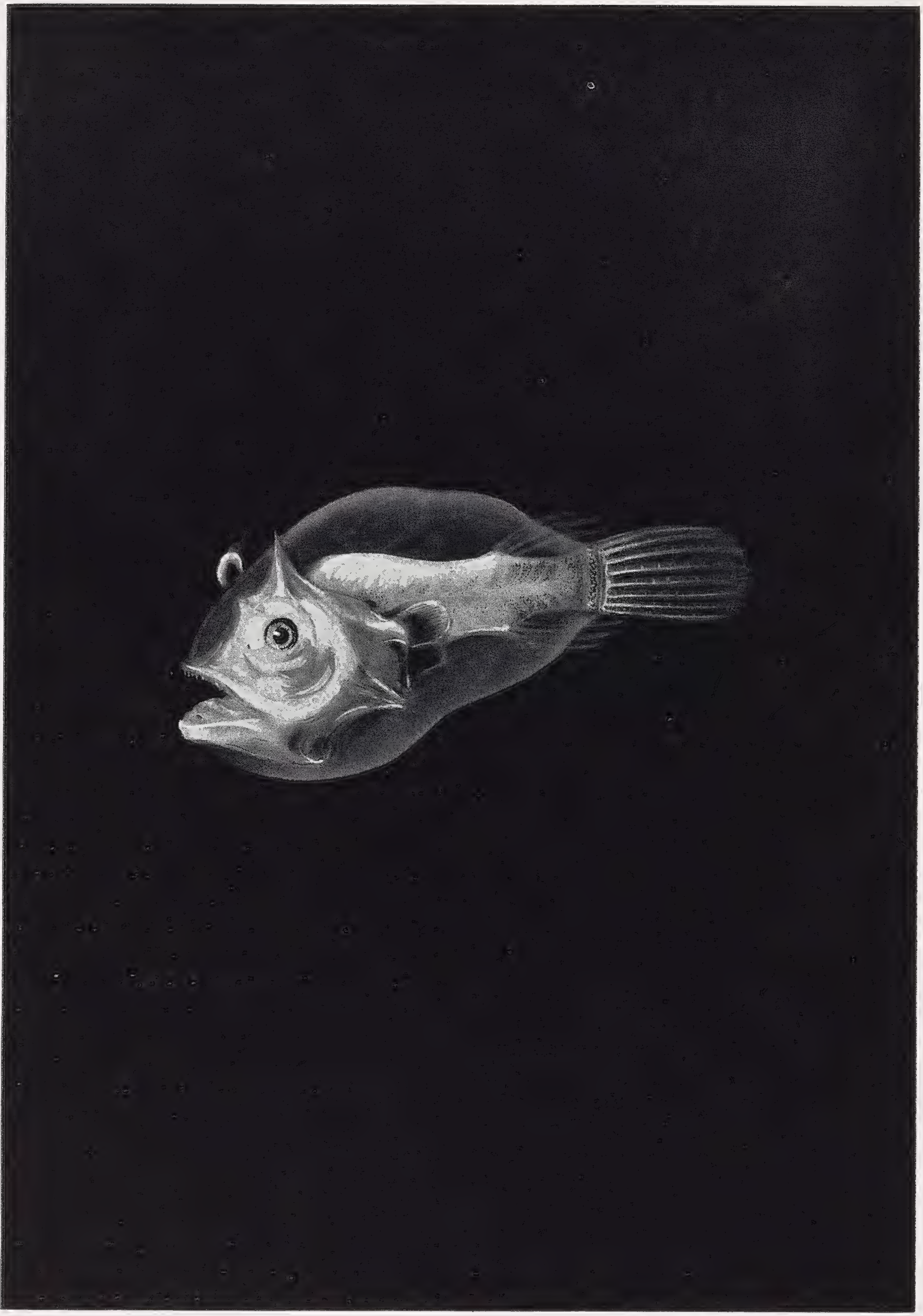
For the next two hours I was wholly absorbed in receiving and dictating messages of all kinds, mechanical, meteorological, and scientific from depths to which living men had never heretofore penetrated.

I experienced with the divers the joy and excitement that was caused by each new observation, but, secretly, I longed to see at first hand these folk of the deep.

Only once during this record dive, when the sphere had almost reached the record depth, was I confronted with intermittent static which was soon controlled on deck. Even the slightest indication of this trouble worried me for on a previous descent static was caused by a severed wire in the hose near the sphere which resulted in a complete break in the connection. The deadly silence during the rapid recall of the sphere with its human cargo was almost unbearable. Had anything more serious happened than a silenced wire? It was only too easy to imagine that the sphere had broken loose from the cable and like the head of a comet plunged downward and downward leaving only a momentary trail of phosphorescence.

But to continue with the present dive, while the sphere, on its way up, hung just below the surface waiting for the last readjustment of the weary creaking booms, the Director's voice came over the phone asking if I were ready to make the next dive. I had longed to see alive, with my own eyes, the creatures which, for months, I had sorted and classified in our hundreds of nets, and with whose skeletons I was so familiar. My imagination was working at top speed, but I refrained from any definite hope until I could be certain that this was not just another joke from below to lighten the strain on board. Between great, smooth, surface rolls, the sphere was landed safely on deck and in a few minutes its human cargo was released. Then the Director and Otis Barton presented me with the strangest and most desirable birthday present in the world. It was all the more surprising because I had forgotten it was my birthday,—all trivial memories had vanished in the face of this great diving success. John Tee-Van welcomed this reverse in responsibility as much as I did for he had had full charge of the deck crew and the manipulating of the mass of machinery necessary for lowering and raising the bathysphere.

The Director gave us final instructions and at twelve-thirty-two we were in the sphere and the giant door was swung into place. The hammering of the ten big bolts began and I winced as I recalled the other dives when I held the deck end of the telephone. Within the sphere this rhythmic clanging was merely monotonous because we were impatient to be below. Tee-Van adjusted the flow of oxygen and clamped the earphones to his head while I pressed my face to the window and waved a signal to Barton that all the connections were ready for the final telephone test. Then the Director, who was managing the deck crew, shouted "you're off," and Barton warned us to brace ourselves. I felt perfectly safe and much more comfortable than when on deck watching the others go down in the sphere. It was unbelievable that I should be in this reversed position with the Director and Barton in charge on deck. Not until the two tons of steel which encased me swayed in mid-air over my friends, poised for a calm, then plunged below the surface, did I realize completely that this was my hour.



A young pediculate fish, with the real body showing through the translucent, balloon-like, outer skin. An illuminated tentacle is just developing on top of the head. Painted by E. M. Bostelmann.

As the sphere broke the smooth surface it faced the bow of the barge and we had a hasty glimpse of the *Gladisfen* trailing her long, slack tow rope. Suddenly, the scene was no longer boats, machinery, and men, but instead the ceiling of the sea quilted in silks and studded with glistening bubbles of air. Then Barton's voice broke a silence that only dead men know and brought an earthly aspect to this canopy mirage which had held our gaze. He reported that we were hanging at fifty feet while the first clamp was attached to the cable and the telephone hose. We strived continuously to control the selfishness of over-enthusiasm and to refrain from occupying more than our half of the quartz window. This was unlike the former dives when the Director had the window alone because Barton had chosen to watch the oxygen gauge, chemicals, and possible places for leaks.

Strange vertical streaks of light broke the solid brilliance of the water, like a sunbeam that has crept through a chink in an old dungeon wall and made the moist mold sparkle in the darkness. Then the tone of the light became more and more amazing. Rays of bright sunlight that had struggled to illumine this world of water vanished and all became a lake of intense bluish green. Air bubbles continued to rain upward, many oozing from the bait tied at the margin of the center window. Hundreds of tiny, white triangular pteropods darted in mid-water with here and there a spray of small, brown, throbbing linuche jellies. A slight swaying of the sphere had been noticeable but we were not conscious of downward motion until Barton reported that we were descending. I remarked at the wonder of being able to observe life beyond the maximum depth permitted to us in the diving helmet. In a few minutes Barton's voice again awakened our other world consciousness and reported that we had reached the depth of two hundred feet. The sphere swayed here for several minutes while another clamp was attached. A comb-bearer jelly, or ctenophore, was wafted close enough to see its eight rows of cilia waving it through space. There followed a large ghost-pale umbrella jelly trailing its four oral stinging tentacles. Then another tiny linuche jelly appeared and disappeared into the bluish green beyond. A swift-swimming silvery fish swerved at the bait, peered at us, then vanished.

Suddenly, the upward course of the jellies and the glistening bubble-like pteropods indicated that the sphere was descending again. Then the Director spoke on the phone for the first time and told us that we had reached the depth of four hundred and ten feet. After a hasty glance to assure those on deck that the door, hose, and window grooves were not leaking we continued to concentrate on the twilight pageant which streamed past our tiny quartz port-hole. We watched a school of colorless shrimps pass in the distance and a startled carangid-like fish as he butted savagely against the window and darted away into blue space. It was difficult to believe that these creatures and hundreds of others could exist in this world of strained sunlight, constant cold, and enormous pressure. At this depth the pressure on the sphere was one hundred and ninety-seven pounds to the square inch, or 2,032,055 pounds total pressure, or 1,016 tons.

Looking directly out, blue seemed to be the dominant tone, and peering straight down we stared into an infinite depth of dazzling blue purple. This was an awful color which excited not only an indescribable force in holding our attention, but a strong desire to descend deeper and deeper "down to the dark, to the utter dark, where the blind white sea-snakes are." We asked the Director to lower us another hundred feet, but his reply was decisive and soon we started to *ascend*. At three hundred feet the silvery fish appeared again and pirouetted around the bait long enough for us to identify it as *Psenes,* many of which have come up dead in our nets. We passed several small cylindrical salpas and many shrimps. *Psenes* continued to dart around the bait while we were held at two hundred feet to have the clamp removed. Suddenly, a long, slender, eel-like leptocephalus undulated into view. With the exception of its glistening eye it might have been a strip of wavy, white, tissue paper. Only two days before a similar leptocephalus had come up alive and I had studied its ways of swimming and breathing but under artificial laboratory conditions, aerating the water and regulating the temperature all night in an effort to keep it alive. Here, in its natural haunt, its movements were much less spasmodic and hurried and it slid past with head poised and slow graceful swaying of the body like those of a giant snake.

We became more excited when we saw the tail of an eel which seemed to dangle near the bait just out of full view. But soon this eel turned into the end of the Zoological Society's flag which draped one side of the Sphere. *Psenes* reappeared and followed as far as the fifty foot halt, where the last clamp was removed. Here we were acutely conscious of the brilliance of the light, made the more dazzling by the glistening Pteropods. Then, as prearranged, the Director pounded on the cable and we answered by hammering on the side of the sphere near the inlet of the telephone hose. Both messages were heard distinctly. In case of a severed telephone connection in the future this signal could be used as a reassurance for those on both ends of the cable.

In a very few minutes we had broken the quilted surface and were swinging high above the deck waiting for a calm during which to land. Before the center plug of the door was entirely unscrewed we heard the outrush of air which sounded like the swash of a tide along a deserted shore. Our ears pained for just a second while becoming adjusted to normal atmosphere. After the big bolts had been whanged off and the giant door swung open we emerged from our steel chrysalis, excited by the unforgettable experience of this hour, and merged again into the scene of boats, machinery and men.

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A Perfect Depth Recorder

WILLIAM BEEBE

IT has been the custom in recent years for oceanographic expeditions, instead of giving an estimated depth of their mid-water net hauls, to state the amount of wire out. Seldom are we told the size of the wire, the trawling angle at which it is drawn, the terminal weight, and the number and character of the collecting appliances.

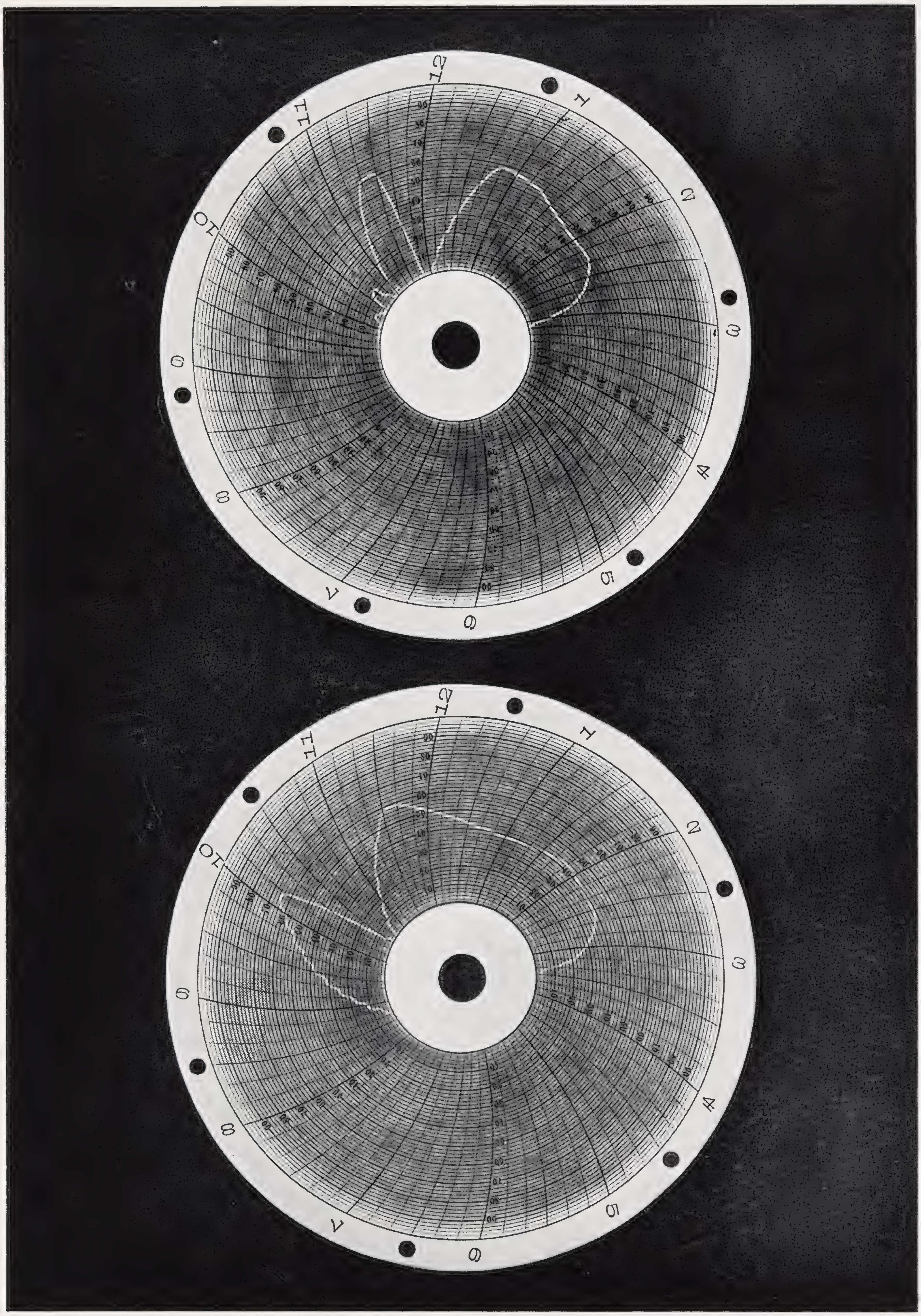
In the Plymouth "Journal of the Marine Biological Association" (Vol. XIII, No. 3, pp. 769-774) Dr. Russell writes of a depth recorder loaned by the British Admiralty which registered exact depths down to fifty metres or twenty-five fathoms. How much deeper it could operate, or what the mechanism was we are not told, but an illustration of a diagrammatic record shows that this instrument is exceedingly accurate at least in shallow depths.

My own work at present deals with depths of five hundred to one thousand fathoms, and with pressures from 1350 to 2700 pounds to the square inch.

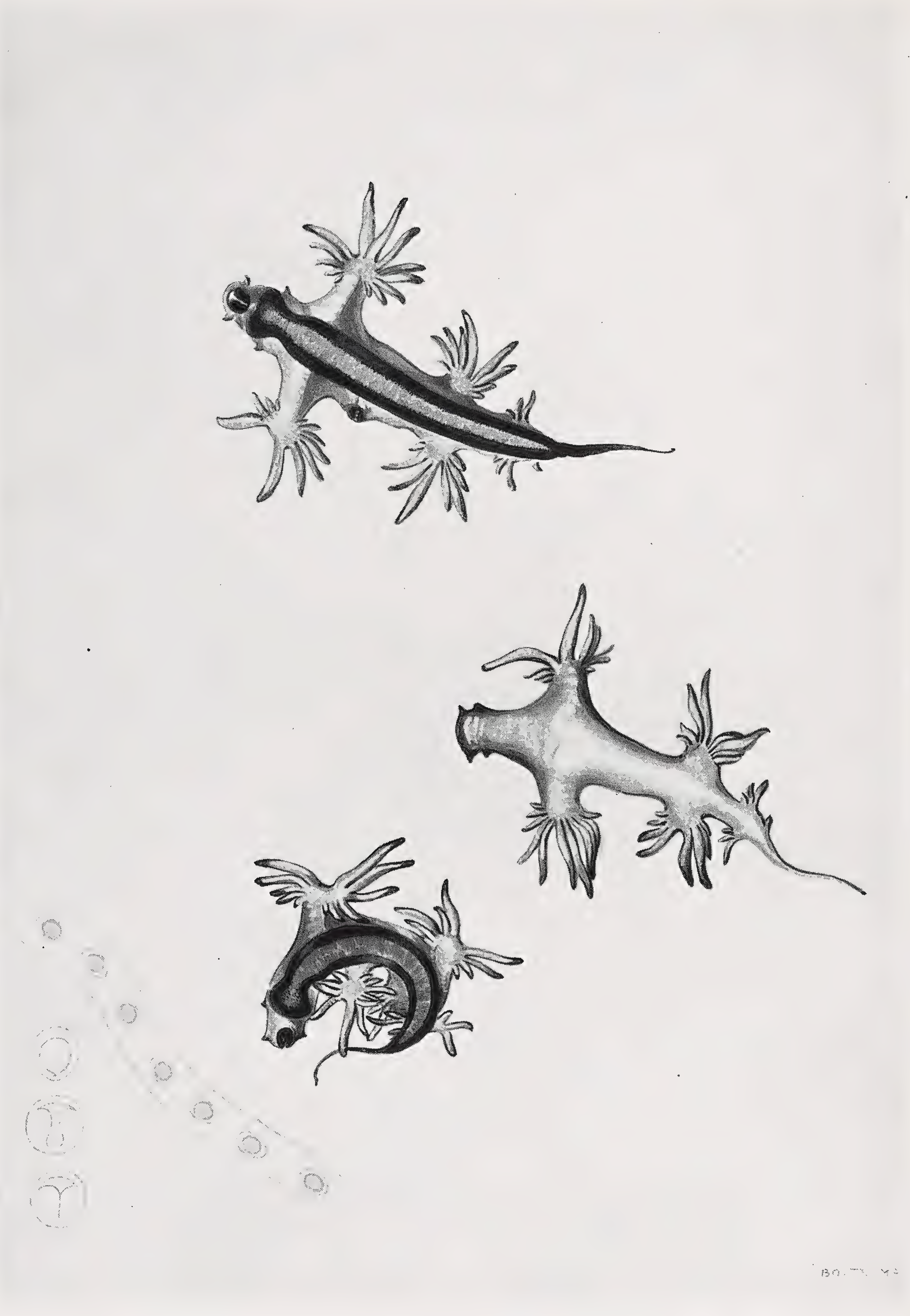
Among a list of unsolved problems connected with the mechanics of oceanographic work which I discussed with Mr. L. R. Smith of Milwaukee was that of tracing the exact course of the deep sea nets. Mr. Smith was eager to help us and had unlimited facilities both in trained engineers and in laboratories in his steel plants.

In 1929 he devised and sent me a circular depth gauge in which the outside pressure was transmitted to two needles on a disk. When brought to the surface the extreme depth was ascertained by the pounds of pressure indicated by the idle red needle. It was found exceedingly difficult to adjust this recording needle so that it would be flexible enough to shift easily, sufficiently stiff to maintain its ultimate position, and yet on the whole to resist displacement from the jerks and vibrations consequent upon being drawn through the water at the end of two miles of cable. Nevertheless, when first lowered vertically to a depth of six hundred fathoms it registered the correct pressure in pounds. There were two dials in the bomb, and on subsequent tests, both vertical and when drawn on regular hauls, the records did not coincide, and the gauge was always half full of water, the pressure forcing it through the pores in the three inches of brass.

In August of the present year a new pressure gauge was sent to me. This is a steel sphere, fourteen inches in diameter. It is divided transversely across the center, the connection being made absolutely tight by a rubber ring fitting into a groove of less diameter, and the two halves fastened by sixteen long bolts and nuts. Great pains were taken to make



Two records made on revolving, soot-covered, paper discs, by our depth pressure gauge. On the upper is seen the track of six vertical hauls; then six nets attached, sent down to 1000 fathoms and drawn for an hour and a half. The lower disc shows a test of the gauge lowered to 1000 fathoms, every 100 fathoms marked by ten-minute intervals; followed by a six-net haul for over three hours.



A rare, pelagic, mid-ocean snail *(Glaucus)*, colored ultramarine and silver, which was blown ashore in the August hurricane. In an aquarium it deposited long streamers of eggs. Painted by E. M. Bostelmann.

the steel particularly dense. Steel castings were eliminated because of the possibility of their being porous. The steel used is a forging presented by Dr. White of the Allis-Chalmers Company. Its weight is two hundred and ninety pounds.

Each half of the bomb is made to contain a separate recording apparatus. This mechanism has a needle which moves over a circular, soot-covered, clock-driven disk, divided concentrically into depth divisions, from surface to fifteen hundred fathoms, and radially into ten minute intervals, totalling twelve hours.

The connection of the recording instrument with the outside pressure is simple and direct. The pressure element is a flattened spiral tube which tends to straighten out when pressure is put in it. The water is admitted through a filtered and delicately guarded opening, actually into the tube, which in turn is so accurately devised and corrected that while it can withstand a maximum pressure of four thousand pounds to the square inch, yet moves the needle on the dial and thus records unerringly the change and duration of change from one to nearly three hundred atmospheres. This depth pressure gauge, devised for operating under such difficult combination of conditions of pressure, salt water, vibration and position was built by Mr. J. B. Kelsey of the Bristol Gauge Company.

We have given it a number of severe trials before beginning to use it regularly, under all possible variants of usage, and the results are clear and accurate to the smallest perceptible degree visible on such a clock-driven, soot-recording device. The technical details of construction will be elaborated in a forthcoming number of Zoologica.

The result is not only important as practical pioneering in this field, but especially gratifying to me as verifying in every respect our estimated depths from the beginning of our work throughout the nine hundred and seventy-odd nets hauled off Nonsuch.

The disks herewith reproduced are from the untouched original records as they came up in the pressure bomb. Two oceanographic activities are indicated on the first disk:

A—Temperature and water samples: Taken at depths of 5, 10, 15, 25, 50, 100, 200 and 1000 fathoms.

B—Five regulation silk metre nets drawn from 500 to 900 fathoms inclusive, for one hour and twenty-three minutes.

First net over	11:53 A.M.
Towing began	12:41 P.M.
Nets started up	2:04 P.M.
Last net up	3:03 P.M.

All of this is distinctly indicated on the disk. The five and ten fathom temperature records are almost invisible, but the succeeding six are clearly shown.

Then we see the faint indication of the first net over just before twelve o'clock, and the four successive, slight, lateral indentations, indicating the several minutes occupied in fastening on each additional net. The straight descent, owing to the slow speed of the tug necessary for attaching the nets, has carried the gauge itself to a depth of one thousand fathoms. The immediate towing speed of two knots and the entering angle of 30° bring the nets at once up to the estimated levels. The last net is shown detached at 3.08 by the gauge, instead of 3.03 as by our watches.

On the second disk we see indicated a descent to one thousand fathoms at 8:40 A.M. This was a test submersion with a thirteen minute interval wait at every hundred fathoms. At 10:10 the cable was hauled steadily in, reaching the deck at 10:30.

A few minutes later six one-meter nets were attached, twelve hundred fathoms of cable paid out and a short haul made of two and a half hours.

These tests were repeated, and in all subsequent hauls of three and four hours duration, the depths, and the contents of the nets both of fish and of plankton confirmed our previous estimates pulled under identical conditions during 1929 and 1930. Which is to say, that the apparatus used by us (six one-metre nets, one hundred fathoms apart) with a given weight at the end of the line, fastened to one-quarter inch cable, and drawn through the water at an angle of thirty degrees and a speed of two knots, gives a depth, when unaffected by abnormal currents, of exactly one-half of the amount of wire out.

Patten Jackson

William Beebe

At the home of Dr. and Mrs. Henry Lloyd of Brookline early last winter I was introduced to a quiet, shy boy of eighteen—Patten Jackson. Without saying more than a very few words he conveyed the impression that he was one of those mortals blessed with the congenital and absolute love of the creatures of earth,—a love, as I so well know, taking no account of money, position, opportunity or friends, but which, unless stifled by main force, wins through to expression. At one extreme it may materialize as a tramp or a gypsy; at the other as a savant, but when developed to the full it cannot be gainsaid.

Later the question arose of Patten Jackson joining my staff and the deciding word was that of one who knew him well and also the exigencies of my work. The night before the boy arrived on Nonsuch I told the others about him and suggested that out of regard for his youthfulness they rather look after him and see that he got into no trouble when out of my sight. As a matter of fact within a week after he joined us he was doing the leading and the looking after. I have never had a member of my staff react so instantly and accurately to suggestions, nor one more perfectly balanced, physically, mentally and socially.

Patten Jackson.
Photograph by P. Crouch.

I was puzzled for a while about what to allot him as his special interest. He saw me examining an otolith of a fish one day and comparing it with the plates in Allen Frost's work. Without any real conviction of his being able to develop a satisfactory technique, I suggested that he try his hand at it. The result was that I worked off and on with him, and watched him achieve, almost unaided, a remarkable technique of dissection, and an ability to draw and describe these interesting concretions little short of astonishing.

In three months we had thoroughly accurate data of the otoliths of ninety species of fish, from one to three pairs in each case, with auxiliary information and measurements of the statocyst and the canals. A dissection of the three semicircular canals of a shark was superior to anything of the kind I have ever seen.

But better than all this were the gropings of the boy after the Whys and Wherefores of it all. From the first he differentiated between the necessary but to-be-subordinated actual dissections and descriptions, and the eventual, sublimated philosophical *raison d'etre*.

Patten was taken ill when at sea with me on the *Gladisfen* on Sunday, September 28th, and in spite of an operation by skilful surgeons at the King Edward VII Hospital, died on October 2nd from acute appendicitis and peritonitis. He would have been as brilliant and as scholarly a scientist, had he lived, as he was a charming gentleman and a perfect companion.

On various expeditions in different parts of the tropics I have lost, from first to last, eleven men from illness or violent death, but all of these have been servants, guides or native savages. This is the first instance of the loss of a white associate or member of my staff.

Log of the Bathysphere

By William Beebe *and* Gloria Hollister

Summary of Dives in Bathysphere

Dive	*Date*	*Position*	*Depth Feet*	*Passengers*
1	May 27	St. Georges Harbor to bottom, ¼ mile off shore 32° 22′ 25″ N, 64° 41′ W.	45	WB & OB
2	June 3	Open Sea, 6¼ miles south of Nonsuch 32° 14′ 30″ N, 64° 40′ W.	2000	Empty
3	6	Open Sea, 9½ miles SxW of Nonsuch 32° 11′ 30″ N, 64° 41′ W.	1500	Empty
4	6	Open Sea, 10 miles South of Nonsuch 32° 11′ N, 64° 39′ W.	803	WB & OB
5	10	Open Sea, 6¼ miles SxW of Nonsuch 32° 14′ 30″ N, 64° 41′ W.	2000	Empty
6	10	Open Sea, 5½ miles South of Nonsuch 32° 15′ 20″ N, 64° 39′ 40″ W.	250	WB & OB
7	11	Open Sea, 5 miles South of Nonsuch 32° 16′ N, 64° 39′ W.	1426	WB & OB
8	11	Open Sea, 5¾ miles SxE of Nonsuch 32° 15′ 20″ N, 64° 38′ W.	410	TV & GH
9	11	Open Sea, 6¼ miles SSE of Nonsuch 32° 15′ N, 64° 37′ 10″ W.	2450	Empty
10	19	Open Sea, 6½ miles SSW of Nonsuch 32° 14′ 30″ N, 64° 42′ 30″ W.	800	WB & OB
11	19	Open Sea, 4¾ miles SxW½W of Nonsuch 32° 16′ 41″ N, 64° 41′ W.	800	WB & OB
12	19	Bermuda Insular Shelf, ¾ miles S. of Gurnet 32° 19′ 30″ N, 64° 39′ 30″ W.	120	WB & OB
13	19	Bermuda Insular Shelf, ¾ miles S. of Gurnet 32° 19′ 30″ N, 64° 39′ 30″ W.	80	WB & OB
14	20	Bermuda Insular Shelf, 1¾ miles S. ¾ W. 32° 19′ N, 64° 40′ W.	350	WB & OB
15	20	Bermuda Insular Shelf, 2 miles SWxS of Nonsuch, approximately ½ mile off nearest reef, to 3¼ miles SWxS½S of Nonsuch. Approximately 1½ miles off shore. 32° 19′ N, 64° 41′ W. to 32° 17′ 40″ N, 64° 41′ 30″ W.	210	WB & OB

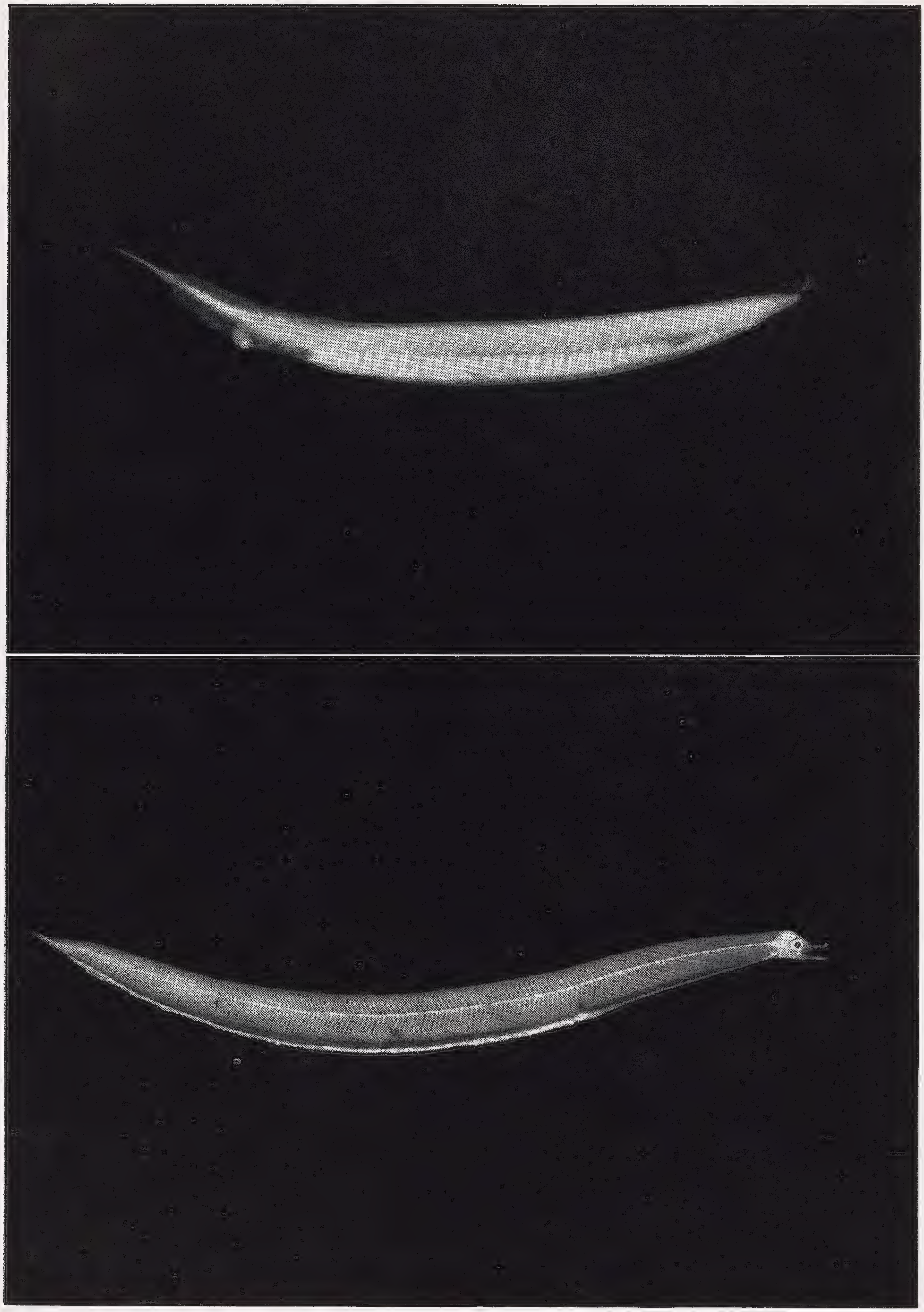
Dive One

Descent of William Beebe and Otis Barton in Bathysphere May 27, 1930. 45 feet. 10:00 A.M.
St. Georges Harbor, ¼ mile off shore
32° 22′ 25″ N, 64° 41′ W.
No notes made.

Dive Two

Test dive of Bathysphere. June 3rd. 1930. 2000 feet. 10:00 A.M. to 1:40 P.M.
Nonsuch party on board 7:30 A.M.
Passed Gurnet's Rock 8:00 A.M.
Stopped to let down Bathysphere 9:30 A.M.

Feet	*Stop*	*Start* A.M.	*Observations*
0		10:00	
50	10:04	10:06	Clamp attached.
250	....	....	Clamp attached.
450	10:13	10:15	Clamp attached.
650	10:17	10:21	Clamp attached.
850	10:23	10:26	Clamp attached.
1050	10:29	10:31	Clamp attached.
1250	10:35	10:37	Clamp attached.
1500	10:43	10:45	Clamp attached.
1700	10:50	10:51	Clamp attached.
1900	10:57	10:58	Clamp attached.
2000	11:00	....	
2000		11:10	
1900	11:13	11:15	Clamp unfastened.
1700	11:21	11:23	Clamp unfastened. Hose twisted about cable.
1500	11:32	11:55	Clamp unfastened. Hose twisted about cable.
1250	12:04	12:17	Clamp unfastened. Hose twisted about cable.
1050	12:24	12:30	Clamp unfastened. Hose twisted about cable.
850	12:35	....	Clamp unfastened. Hose twisted about cable.
650	12:46	12:51	Clamp unfastened. Hose twisted about cable.
450	1:02	1:06	Clamp unfastened. Hose twisted about cable.
250	....	....	Clamp unfastened. Hose twisted about cable.
50	....	....	Clamp unfastened. Hose twisted about cable.
0	1:40		



Upper: Bermuda Amphioxus or Lancelet, which closely resembles the ancestral fish. It has no bony vertebrae, nor proper jaws, and only a single median eye. It lives buried in the sand near Nonsuch. Photograph by J. Connery. *Lower:* A transparent larval eel *(Leptocephalus)* which came up in a net from a depth of three-quarters of a mile. Photograph by J. Connery.

In this descent about 45 turns of the telephone and electric light hose were twisted about the steel cable. These were caused by the untwisting of the turns which the cable had acquired as it was reeled from its original wooden drum onto the winch.
Started toward Nonsuch 1:45 P.M.
Arrived Nonsuch 3:20 P.M.
Weather: Clear, bright sun.
Wind: SE., 2.
Sea: Calm, low swell, small white caps; swell and white caps increasing in P.M.
Sylvester and crew of 12 men on board.

Position:
6¼ miles south of Nonsuch.
32° 14′ 30″ N, 64° 40′ W.

Traveling time:
Down—41 minutes, 100 feet every 2 minutes.
Up—95 minutes, 100 feet every 4.75 minutes.
Total average time per 100 feet: 3.4 minutes.
Total average time per 1 foot: 2 seconds.

Dive Three

Test dive of Bathysphere. June 6, 1930. 1500 feet. 9:25 to 11:00 A.M.

Feet	*Stop*	*Start*	*Observations*
		A.M.	
Surface		9:30	
200	9:34	9:37	
400	9:39	9:41	
600	9:43	9:45	
800	9:49	9:50	
1000	9:53	9:54	
1200	9:56	9:57	
1400	10:00	10:01	
1500	10:03	10:13	
1400	10:16	10:18	
1200	10:20	10:22	
1000	10:25	10:26	
800	10:30	10:31	
600	10:33	10:36	
400	10:40	10:42	
200	10:44	10:45	
Surface	10:50		
On deck	11:00		

Bell disappeared at 138 feet (42 meters). Movie in sphere run by electricity for 1 minute at depth of 1500 feet. No twist to hose, which was held away from cable by ropes about 3 feet long clamped to hose and cable.
Windows not effected by trip.
Camera still in position in center window.
About a quart of water in bottom.

Position:
9½ miles SxW of Nonsuch.
32° 11′ 30″ N. Lat., 64° 41′ W. Long.

Traveling time:
Down—22 minutes; 100 feet every 1:47 minutes.
Up—25 minutes; 100 feet every 1:67 minutes.
Total average time per 100 feet: 1:57 minutes.
Total average time per 1 foot: 9 seconds.

Dive Four

Descent of William Beebe and Otis Barton in Bathysphere, June 6, 1930. 800 feet. 1:00 to 2:00 P.M.

Feet	*Stop*	*Start*	*Observations*
		P.M.	
Left deck		1:00	Clamps attached at every 100 ft.
50	1:03	1:04	Many tiny Jellyfish.
100	1:05	1:06	Jellyfish, blue light, temp. 83°. 2 Linuche jellies.
150	1:07		Large jellyfish.
200	1:08	1:09	
250	1:10		
300	1:12	1:13	Small Shrimps.
350	1:15		
400	1:16	1:17	Several Myctophids or Lantern fish.
500	1:20		
600	1:25	1:28	Salpa string, 3 luminous fish, small. Many Shrimps, Jellyfish, 12-inch fish, pale blue moonlight, red still present of Shrimp in bell, temp. 78°.
700	1:30		12 fish swimming upright, light still present. Large, dark forms seen moving in distance.
800	1:32	1:37	Many sparks, several 4-inch dark fish, temp. 76°.
803			
800	1:37		
700	1:38		
600	1:40	1:41	
500	1:42	1:43	
400	1:44	1:45	
300	1:46	1:47	
200	1:48	1:49	
100	1:50	1:58	
Surface		2:00	

Position:
Ten miles south of Nonsuch.
32° 11′ N. Lat., 64° 29′ W. Long.
Over 1500 fathoms of water.

Traveling time:
Down—24 minutes, 100 feet every 3 minutes.
Up—10 minutes, 100 feet every 1¼ minutes.
Total average time per 100 feet: 2:17 minutes.
Total average time per 1 foot: 1:3 seconds.
Bell in sight for 138 feet or 42 meters.
Temperature: On deck 87°, 600 feet 78°, 800 feet 76°.
Pressure: 360 lbs. per square inch.
803 feet, 134 fathoms, 245 meters.

Dive Five

Test dive of Bathysphere, June 10, 1930. 2000 feet.
Duration about 2 hours. On deck again 11.10.
No tangle or twist of hose.
No water in bottom of bell and no change in suspected crack in center window.
Three feet of rubber hose forced into sphere.

Position:
6¼ miles SxW of Nonsuch.
32° 14′ 30″ N. Lat., 64° 41′ W. Long.

Dive Six

Descent of William Beebe and Otis Barton in Bathysphere, June 10, 1930. 250 feet. 12:54 to 1:06 P.M.

Feet	*Stop*	*Start*	*Observations*
		P.M.	
			Lobster as bait below center window. Explorers' Club and Zoological Society Flags attached on outside.
		12:44	W. B. and Otis Barton both in Sphere.
		12:45	Door in place. Phone tested.
		12:52	Sphere left deck.
		12:54	Sphere in water. Lights tested O. K.
4		12:56	Sun's rays are straight down, look like rain pouring down.
100		12:57	Many small Jellyfish.
150		12:58	2 Caranx-like fish swam past rapidly. 1 good-sized Aurelia.
200		1:00	2 long strings of Salpa. Feel lighter when lowered, same as in an elevator.
		1:01	Phone connection cut off after several seconds of bad static.

Feet	*Stop*	*Start*	*Observations*
		1:02	Connection re-established.
		1:03	Shut off again. Batteries changed, all connections and end wires tested and tightened to no avail.
200	Up trip	1:04	Light switch cut off, and motor shut off.
		1:05	Still no phone.
		1:06	Sphere on surface.
		1:08	Sphere on deck. Director saw 24 Jelly fish on way up.

Position:
5½ miles south of Nonsuch.
32° 15′ 20″ N. Lat., 64° 39′ 40″ W. Long.

Traveling time:
Down—5 minutes.
Up—2 minutes.

Dive Seven

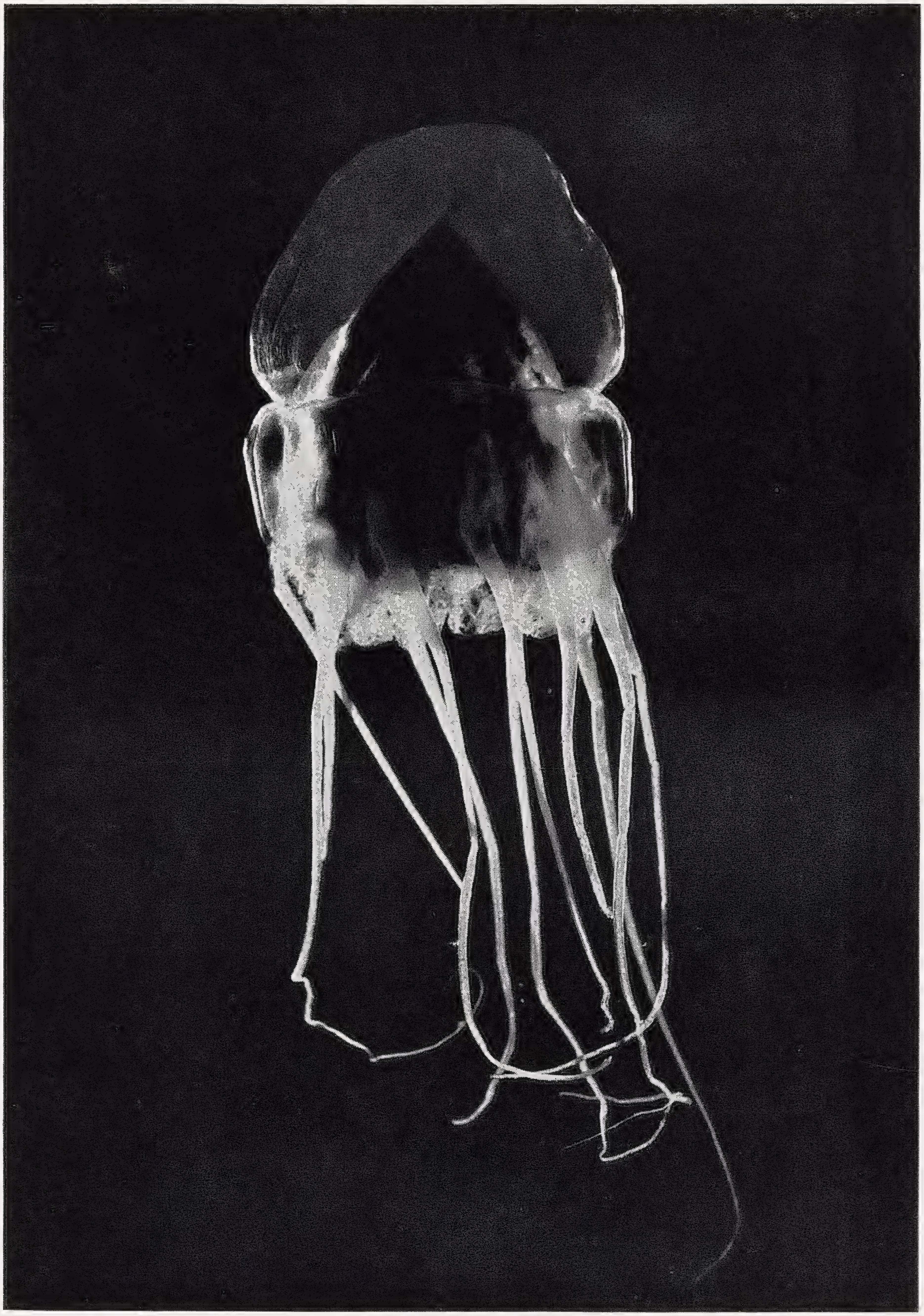
Descent of William Beebe and Otis Barton in Bathysphere, June 11, 1930. 1,426 feet. 9:50 to 11:52 A.M.

Feet	*Stop*	*Start* A.M.	*Observations*
Sph. left deck		10:03	Clamps attached every 200 feet.
In water at		10:04	Ship's rope looks like sea-serpent.
50	10:05	10:07	20 or 30 small round jellies of several sizes.
100		10:08	Red gone, color plates black. Black paint around windows of sphere a great help. Linuche jellies.
150		10:09	
200	10:10	10:11	Pilotfish around bait, 6 inches long, pure white with 8 jet black bands.
250		10:13	No red or yellow in sunlight. More jellies, tail of pilotfish seen again.
300	10:13.5	10:14	Otis saw pilotfish, fish many colored at surface but looks white.
400	10:15	10:17	Can just read print without light. W. B. writing, can't see, yet it seems brilliant. It is as dark here as it was at 800 feet just after noon time. Two strings of Salpa. Shrimps look pure white.
450			School of prawns.
500	10:18	10:19	Transparent fish with only food visible. 3 inches long. Snapper.
550		10:19.25	Temperature 76°. Large leptocephalus. Many Cavolinia. Several Myctophids.
600	10:20	10:21	Bright inside, but can't see outside.
650		10:22	Flashes of light in distance. Jet black jellyfish 3 inches long.
700		10:23	Many little Shrimps—like small tentacles. Argyropelecus. Cubiceps near glass.
750		10:24	Temperature 74°. Nice and cool.
800	10:25	10:26	Pretty dim. Meter wheel reading is 237.
850		10:27	20 or 30 spots going in one direction, can't identify.
900	10:28	10:29	Several mists of little Shrimps. Large Serrivomer.
950		10:30	Pretty dim, can't see anything, trying to read, Otis could see plates in book but not print.
1000	10:31	10:33	Can see loop of slack hose. Hose has not pushed into the sphere yet. Reading of meter is now 298.
1050		10:34	Blacker than blackest midnight, yet brilliant. 20 little fish which might be Argyopelecus with lights; if so, then these are the young.
1100		10:35	Thick, long, rat-tailed Macrurid-like fish with 6 lights went around bend of hose.
1150		10:36	
1200	10:37	10:38	Beam of light showing clearly. Meter wheel reading is 358. Idiacanthus. Two Astronesthes.
1250		10:40	Fish 5 inches long, like Stomias. 3-inch shrimps, all white. Argyropelecus in light beam. 2 luminous pale white jellies.
1300		10:41	6 or 8 shrimps. 50 or 100 fire-fly-like lights. Small squid in light which seems to have no lights, went down to bait. Cyclothones. Two-inch shrimps.
1350	10:42	10:43	Light very pale. Temperature is 72°. Meter wheel reading is 403.
1400	10:44	10:46	Looking straight down is the blackest black of hell. Meter wheel reading is 418.
1426	10:47		5 Argyropelecus, dozens of jellyfish, many large shrimps, white, by bait, tremendous flash. Stomias.
1426		10:47.5	
1200	10:50	10:51	Jellies going past. Dozen little flashes going on and off. Squids 2 inches long around light. Can see edge of flag.
1150		10:51.5	
1100	10:52	10:53	18-inch fish, largest one yet.
1000	10:54	10:57	Constant drift of little shrimp across glow, also sparks. Walls of tank damp with sweat.
950		10:59	Big loop in hose. Large myctophid floating on surface by cable; probably a joke.
800	11:01	11:03	Can still see phosphorescence. Something flashing around bait, can't see it. Temperature 72°. Little round bodied fish went past with no lights. Not nearly as much light as other day. Walls in tank are cold.
700		11:04	Pilotfish back again. Beam from flash light became invisible.
600	11:06	11:10	Large white body in distance, can't make out shape. Deep-sea fish on board.
550		11:11	
500	11:12	11:13	Faint lights in distance.
400	11:14	11:15	Shrimp picture in "Depths of the Ocean" still jet black. Can just read with lights off. Jellyfish going past. Puffer 1 inch long swam slowly across window. W. B. knows that he saw Cyclothones.
350		11:16	Little points of light in strings—reflection. 5 loops of rubber hose around cable.
300	11:17	11:19	Something around bait, more hose loops.
250		11:20	
200	11:21	11:23	Good and light. Saw lighted thing which looks like Salpa. More jellyfish. At least 10 loops in hose.
150	11:25	11:26	Fine and clear now. Bathysphere reported in sight from deck. No trace of red in shrimp in bottle.
Surface		11:30	
On board		11:32	
Out of Sphere		11:52	

NOTE: Meters as recorded are not actual meters but the recording of the meter wheel calibrated for ⅞ inch cable instead of its original ½ inch. With this meter-wheel 150 feet of cable equals 44 meters.

Position:
Five miles south of Nonsuch, over a bottom 750 fathoms down. Drifted farther out.
32° 16′ N. Lat., 64° 39′ W. Long.

Traveling time:
Down—27 minutes, 100 feet every 1:8 minutes.
Up—23 minutes, 100 feet every 1:5 minutes.
Total average time per 100 feet: 1:39 minutes.
Total average time per 1 foot: 1 second.



Hyacinthine Leaf Jelly *(Periphyllum hyacinthina)*. A wonderfully beautiful deep-sea jelly, purple, coppery and pale blue. This individual came from a depth of three-quarters of a mile.

Temperature on Deck, 88°; 550 feet, 76°; 750 feet, 74°; 1350 feet, 72°; 800 feet, 72°.

Pressure: 652.7 pounds per square inch on Sphere, or 6,732,469 pounds. Total pressure in tons is 3366.2 tons.

Depth: 1426 feet, 237.6 fathoms, 435 meters.

Telephone connection worked well during the whole dive with the exception of the last 150 feet when there were several breaks and bad static. Phone was tested on the average of every minute when messages were not being sent up. Light signals were tested twice; 1 meaning O.K., 3 meaning pull us up. This is to be the means of communication in case the phone connection is cut off.

Calculations for Pressure on Diving Sphere at 1426 Feet

Circumference of sphere equals 180 inches by measurement with a steel tape. In these calculations the protuberances on the sphere are ignored and it is considered to be a perfect sphere.

Diameter of sphere . . . . *57.3 inches*
(Area of sphere . . . D, x pi)

```
   57.3
   57.3
  -----
   1719
  4011
 2865
 ------
3283.29    . . . .  3283.3
                     3.1416
                    -------
                     196998
                     32833
                    11332
                   32833
                  98499
                 -----------
                 10314.81528 square inches to
                             surface of the sphere.
```

Pressure at 1426 feet.
(Pressure at depth = 14.7 lbs. per 10 meters.)
1426 feet—divided by 6 = 237.6 fathoms
237.6 fathoms = 433.42 meters
433.4 meters = 43.4 atmospheres

Adding 1 atmosphere for pressure at surface of the water, we have a total of 44.4 atmospheres—

```
   44.4
   14.7
  -----
  652.7 lbs. — pressure per square
               inch on the sphere.

10314.8 square inches
  652.7 lbs. per square inch
 -------
  722036
 206296
515740
618888
---------
673246996 — pointing off 2 places we have the
            amount of pressure as 6,732,469 lbs.
```

Translated into tons, we have the following total pressure . . . . *3366.2 tons*

Dive Eight

Descent of Gloria Hollister and John Tee-Van in Bathysphere, June 11, 1930. 410 feet. 12:32 P.M. to 1:15 P.M.

Feet	*Stop*	*Start*	*Observations*
		P.M.	
		12:32	Both in bell.
		12:34	Phone test.
		12:34.15	Motor started. Light test. Door in place.
		12:34.50	Boom lifting. Door hammered into place.
		12:40.30	Lifted off deck.
Surface		12:41.30	In water.
50	12:44.50	12:46	50 foot clamp in place. Bubbles coming past. Still luminescent glow. No apparent change in color. Little white darts all over place. May be Pteropods.
152			Small brown jelly. (45 meters on wheel.) Little bubbles still flashing past.
197	12:48	12:49	200-foot clamp in place. One fish coming. Can still see a little red in shrimp. (Looked purplish brown.) Large white jellyfish. Blue color seems to be losing a little of its yellowness. Light test O. K. One more brownish jelly.
		12:50	Phone test.
305		12:50.30	Phone test. More jellies. Pale translucent jelly. Large bubbles still going up. Amount of light is quite surprising. Large bubble just went up.
		12:52	1 shrimp.
400	12:52.50	12:56	Flashes of light are Pteropods. Certain it is triangular Pteropod. Holding at 400 feet. Director on phone.
		12:55.30	Phone test. See Director's streaks.
410	12:56	1:00	Dropped to 120 meters (410 feet actual measurement) by the meter wheel.
410		12:56	Temperature 76°. 1 Brown jelly. 1 Sapphirina? Carangid of some sort, about 2 inches long.
410		1:00	Going to pull up. Psenes fish. "Take it slowly."
		1:01	Oxygen pressure 800 pounds. Motor off. 1 jelly.
		1:03	1 salpa. 1 transparent eel-like leptocephalid.
200	1:03	1:04	200 foot clamp off. Psenes, silvery fish passed again. Porpoise sighted.
		1:06	Too much light. Gladisfen to slow down.
		1:06	1 brown worm passing.
		1:07	Can see tape from draped flags.
50	1:07 1:09	1:08 1:10	Psenes went past again. 50 foot clamp off. Pounding on cable 3 times. Heard distinctly.
		1:11	Pounded 4 times, heard O. K. Shrimp is getting red. Gloria can see atomic theory working!! (joke). Bubbles passing by.
		1:11	Plainly in sight. Going to stop at surface. Up for photos.
		1:13	Above deck.
		1:14	On deck.
		1:15	Door open, phone off. Very little pressure. Slightly noticeable to inmates when last amount of pressure was released.

Position:
Open sea, 5¾ miles SxE of Nonsuch.
32° 15′ 20″ N. Lat., 64° 38′ W. Long.

Dive Nine

Test Dive of the Bathysphere, with camera, June 11, 1930. 2450 feet. 1:50 to 4:18 P.M.

Feet	*Stop*	*Start*	*Observations*
		P.M.	
Surface		1:50	Camera mounted in window.
2450	2:45	2:50	Camera run for 75 seconds. 2450 feet —836 meters; to phone connection —841.

Feet	*Stop*	*Start*	*Observations*
Surface		4:17	Light test at 4:16.
On deck		4:18	Bad twists of phone cable around steel cable from the beginning. No water in Sphere. Barton discovered camera had not worked!

Position:

6¼ miles SSE of Nonsuch.
32° 15′ N. Lat., 64° 37′ 10″ W. Long.

Traveling time:

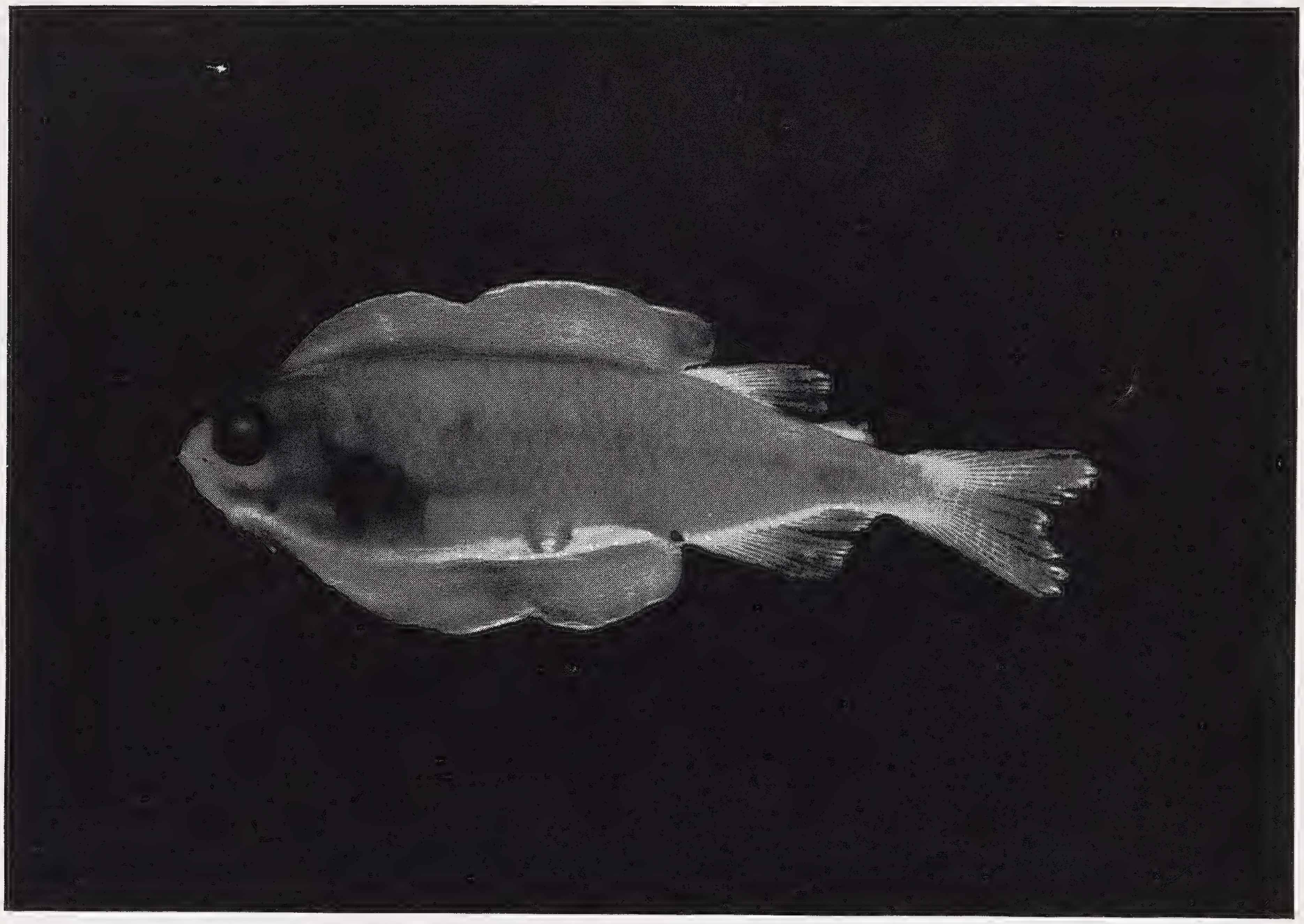
Down—55 minutes.
Up—1 hour 26 minutes.

Total average time per 100 feet: 2:53 minutes.
Total average time per 1 foot: 1:73 minutes.
Pressure at 2450 feet: 1102.5 pounds per square inch or 5686 tons total.

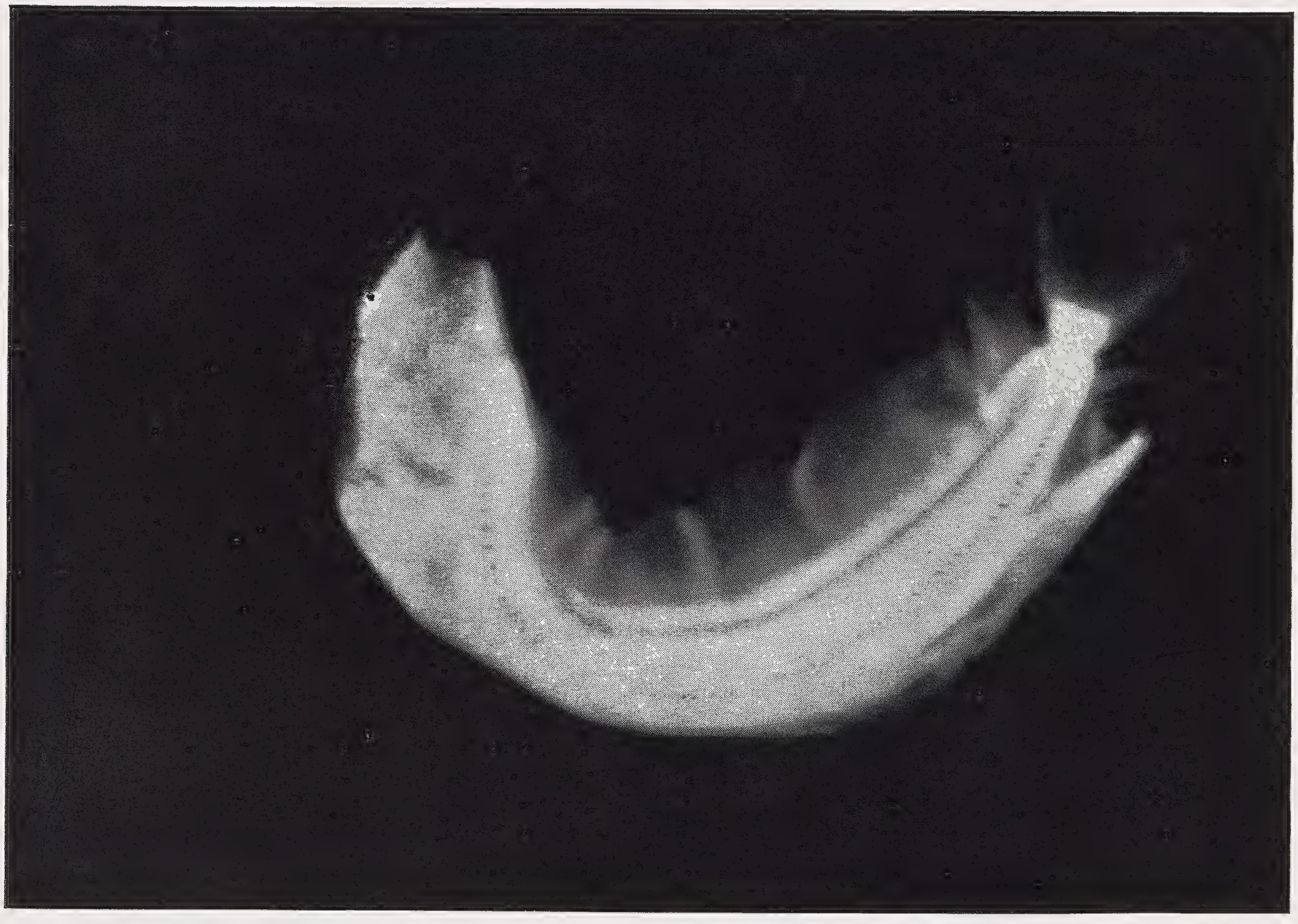
Dive Ten

Descent of William Beebe and Otis Barton in Bathysphere, June 19, 1930. 800 feet. 9:48 to 11:32 A.M.

Feet	*Stop*	*Start* A.M.	*Observations*
On deck		9:30	Both in Bathysphere.
		9:35	Door on, opened to give Director an elastic band.
		9:42	Door hammered in place again. (2 men working, 16 men audience.)
		9:45	Director says that bait, fish hooks, and thermometer are in good position. ("Loud Pilchards" used as bait—these wrapped in cheese cloth and tied to bracket which Barton rigged to left window. 6 small baited fish hooks dangled from the end of the bracket. An ordinary thermometer was tied to outside of left window.)
Surface		9:48	Just below surface red of spectrum diminished ½ width.
20	9:49	9:51	Thin line of red mostly orange; gone from 700 to 650 (reading of spectroscope). Can see hull of Ready plainly. Number 4 disappeared completely on the smallest adjustment of the Exposuremeter (2).
50	9:52	9:55	Clamp. 4 little brown jellies. Number 4 as strong as before. Red absolutely gone. Orange at 625. Other bands as usual. 3 big Bonito-like fish about 15 inches long.
100	9:56	10:00	Barton checked up instruments and reported everything all right. Phone tested, working fairly well at this point, slight static, especially when Barton moves around. Emergency signals tested with lights by Barton and Hollister at instruments. Six 3-inch silvery fish. Orange much narrowed at 660. Rest of spectrum normal. Number 4 disappears at a point above the lowest (2.4) Salpa, 3 strings, 2 transparent jellies, 3 transparent fish shaped like Psenes. Dozens of transparent jellies about ½ inch long. Little white threads going through water are Sagitta.
150	10:02	10:03	Just a thread of orange. Visibility much better since walls have been painted. Baited fish hooks clearly visible in middle of window. This idea is a great success.
170			Numerous Sagitta. Little Pteropods flapping.
200	10:05	10:06	Clamp. Number 4 disappeared at the half way turn (5). No orange left. Faint yellow well within the 600; less green than at surface, less blue and more violet. Static on phone becoming bad again, but distinct break in wire not noticed yet. Light signals tested in case phone should be cut off.
250	10:07	10:08	Temperature reading is 76°. Air very sweet in Bathysphere. Number 4 disappears two-thirds around the circle (5.6). Violet and blue the same as above. Green dim but almost as wide; rest dirty yellow with brown edge.
300	10:11	10:13	Psenes took a bite at the hook. Backed away. Psenes silvery white with no blue at all. Looked at one of the hooks again and went away. Barton saw this also. Number 4 just visible opened, but disappears at a little twist (11.3). Whole spectrum dim. Yellow almost gone, its dirty brown edge towards red end. Violet seems narrower than at the surface. Phone not working well—intermittent static and Barton's voice not carrying clearly.
350	10:14	10:15	Next time try fresh fish as bait. Jelly and Sagitta seen. Number 4 visible only wide open (16). Brown edge of green gone completely. Analysis of spectrum; 50 per cent blue-violet; 25 per cent green, and 25 per cent colorless pale light.
400	10:16	10:17	Small fishes 1 inch long. Number 4 wide open shows as a mere trace of light color, not as a number. Shifted to 30, which I can just distinguish at lowest aperture (2). 2 silver eels 6 inches long, stopped at the bait, then hurried away. Spectrum same but duller; violet has completely taken the place of the blue.
450	10:20	10:21	Can still see Number 30 at the lowest aperture faintly (2). Blue all gone. Nothing but violet and faint, faint green. 3 eels. 4 Cyclothones in light beam, but absolutely invisible without the light. Satisfactory light test. Phone connection poor, but can get messages.
500	10:22	10:29	Temperature reading at 10:22 is 70°. Number 30 just barely visible, not recognizable as a figure at the lowest point (2). Every color of the spectrum has gone except violet. If I didn't know that there was green at the other end, I could not have named the color. Light turned on for temperature reading. 68° at 10:26. Light out. This light test was reflected on the instrument board on deck. I can still read large print. On circular color chart there is not any color which can possibly be named.
550	10:30	10:30.5	Can still see Number 30 as a faint blur at the lowest twist. A pilot fish.
600	10:31	10:35	Two pilotfishes. Number 30 still visible, not as a number, but as a blur at the lowest twist. Temperature at 10:34 was 70°. Spectrum very dim. No color.
650		10:36	
700	10:37	10:40	Temperature a little over 70° at 10:37. Spectrum a dull gray toward center, fading out on each side. No color whatever. Number 30 is still detectable at the lowest point. Very bad static with complete break in connection for several seconds at a time. Hollister sent one flash on electric light signifying that all was right on deck.



A larval Lanternfish or Myctophid. The curious finfold which surrounds the body and precedes the vertical fins is still well-developed, but is slowly being absorbed.



A larval Melanostomid fish. with the finfold still complete as a delicate, waving veil. The real fins are faintly visible near the tail. Photographs by J. Connery.

Feet	*Stop*	*Start*	*Observations*
			We responded with light and then the phone connection returned and static lessened.
750		10:41	A fish 3 feet long went past. Largest one seen yet. It had a long, sharp tail and was Melanostomid-like. 3 more transparent fish swam past.
800	10:42	11:00	Lights out. Still detect Number 30 at the lowest (16). Spectrum dull gray, fading rapidly out. Spectrum pale grayish white, lightest in the heart of what once was blue, at the 520th wave line; fading out slowly toward violet end, much more abruptly toward the red end. Not a particle of the faintest color distinguishable by either Barton or myself. Temperature 70° at 10:47. 2 dark fish about 3 inches went past. 2 spotted fish about 1 inch long went past. 2 more fishes like Cyclothone went past the light. (Engine speeded up.) Numerous fishes. Still brighter. Argyropelecus, 15 or 20. Many shrimps. About 30 spots to the second flash in all directions. Conditions are grand. Continuous passing like the play of sunbeams. Absolutely invisible outside light. Another large fish. Worm all broken to pieces in light. Things are gathering around the light. Taking a movie, 10:50. 10:56. Took a short movie. No diminution of speed; fish swim as fast as at the surface. 40 little fish like Cyclothones all together. Silver eel. Thermometer reading just the same at 10:52. Certainly this is the Silver Zone. Can read large print. Bad telephone static. For several minutes static continued and many times the connection was dead. This became so serious that it was thought best to raise the Bathysphere immediately.
650			2 silver eels around light. 2 Psenes.
600	11:04	11:05	
550	11:06	11:07	String of jellyfish the whole time. Saw black forms in distance. 4 are coming nearer.
500	11:08	11:10	Black fish went by in distance. Puffer 3 inches long. Something went overhead.
490			Violet, and palest green and nothing else.
450		11:11	Saw leptocephalus right past hooks. It wound in and out, and was about 6 inches long.
400	11:12	11:15	Psenes, brilliant gold in the light. Temperature 69° at 11:13. 2 large fish.
390			Violet and green. Yellow green to the end of spectrum on red side.
350		11:16	Psenes again. Very bad telephone static.
300	11:16	11:18	Violet is normal. Blue and green narrow. Goes off in light reddish brown line. Transparent jelly. Color chart, all colors look normal except red, which looks brown.
275			Little silver fish 1 inch long.
250		11:19	
200	11:20	11:22	Temperature 72° 11:21. Brown but no red in spectrum. Hooks perfect indicator of direction sphere is going.
150		11:22.5	
100	11:23	11:28	Triggerfish around hook, 2 inches. Alternate black and white bands from snout to tail. Taking movie. Hooks indicate strong current. Fish working hard to keep up with it. Leptocephalus 12 inches long, very slender like a snake. More jellies. Bell in sight. Leaving triggerfish behind.
80			Director wants a mask made to keep his breath from the glass. Small leptocephalus. 6 Pteropods.
50	11:29	11:30	Distinct line of orange.
20	11:31	11:31	More fish. 74° temperature at 11:31. Lost Ipnops!! (joke). Grand dive.
Surface		11:32	
On deck		11:34	

Position:
6.5 miles SSW of Nonsuch.
32° 14′ 30″ N. Lat., 64° 42′ 3″ W. Long., at 11:20 A.M.

Deck temperature, 88°; 250 feet, 76°; 500 feet, 68°; 600 feet, 70°; 700 feet, 70°; 800 feet, 70°; 400 feet, 69°; 200 feet, 72°.

Traveling time:
Down—22 minutes.
Up—15 minutes.
Total average traveling time per 100 feet: 2:31 minutes
Total average traveling time per 1 foot: 1:3 seconds.

Note to Dive Ten

My intensity records made on Dive Ten were taken by means of a photographic "Cinophot." I have repeated these records of brightness by means of the illumination from an elongated wooden box enclosing an incandescent lamp. This runs on a track, thus approaching or receding from an end window fitted with opal glass. Mr. Norman Macbeth of the Macbeth Daylighting Company has very kindly checked these records on one of his delicate Illuminometers, and has translated their corresponding values into Millilamberts and Candlepowers.

Brightness

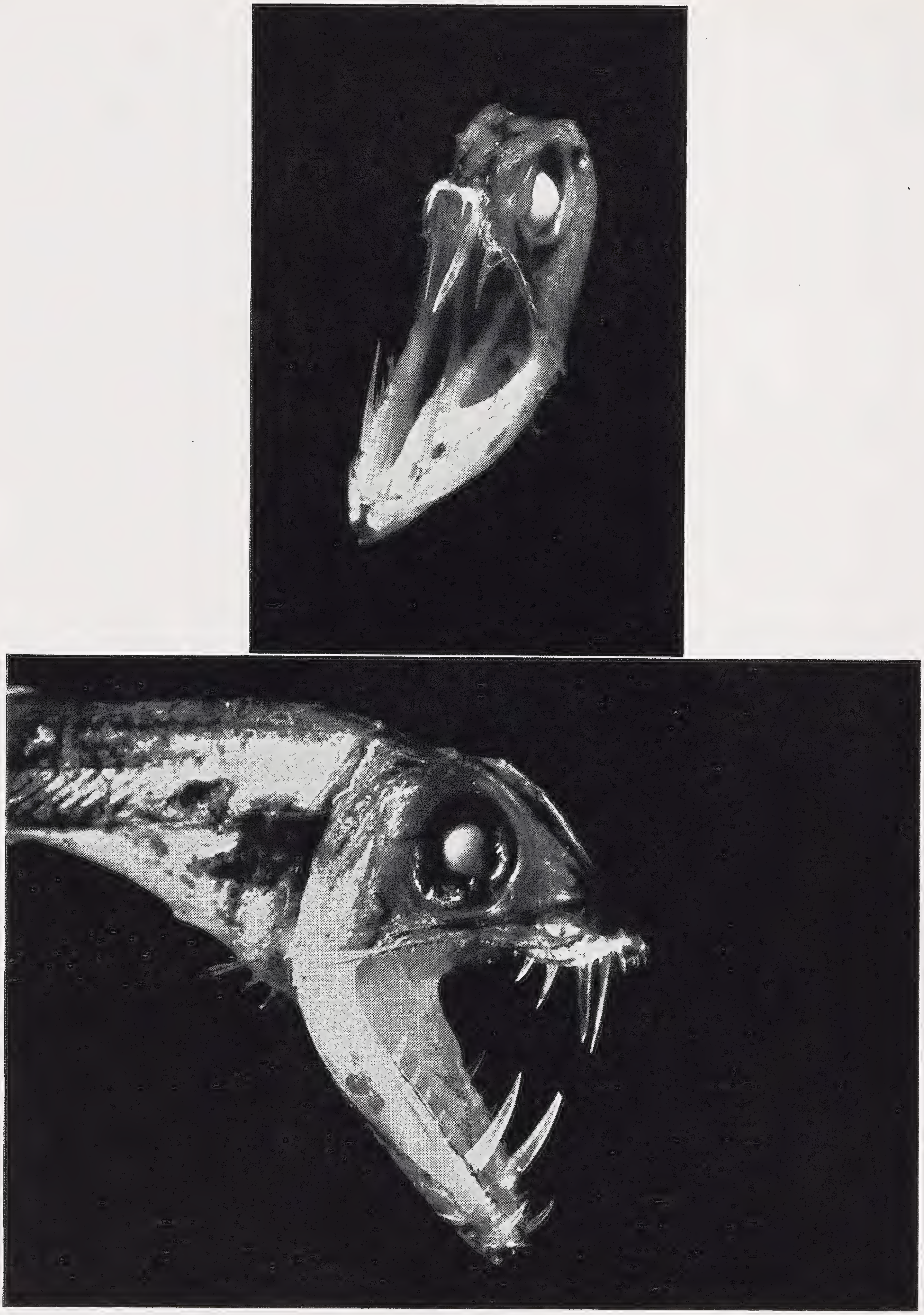
Depth in Feet	*Milli-lamberts*	*Candles per sq. foot*	*Candles per sq. inch*	*Candles per sq. cm.*
50	36.00	10.40	0.0738	0.0114
100	11.40	3.37	0.0234	0.0036
200	1.37	0.41	0.0028	0.0004
250	0.72	0.21	0.0015	0.00023
300	0.53	0.15	0.0011	0.00017
350	0.40	0.12	0.0008	0.00013
500	0.075	0.02	0.0001	0.000024

As far as my eye could record, there was no further change from 500 feet to the extreme depth of this particular dive, of 800 feet.

The illumination term "Brightness" is defined by Mr. Macbeth in order to make the above table more understandable. An object is said to be bright if it emits or reflects light, and through the fact of its brightness becomes visible. Used in this sense the term "bright" is purely qualitative, and, in order to fix the brightness of objects for comparison purposes, a quantitative scale is necessary.

In order to supply such a scale, the brightness of a surface when viewed in any direction is considered to be the ratio of the luminous intensity or flux—either emitted or reflected—expressed in candlepower measured in that direction, to the area of this surface projected on a plane perpendicular to the direction considered.

The brightness of a surface is always expressed in terms of luminous intensity per unit of projected area. The units used to define it are the lambert, millilambert, candlepower per square inch and can-



A sabre-toothed fish from 700 fathoms *(Omosudis lowi)*. In spite of its great fangs this fish is sometimes overcome and swallowed by a fish one-third its size (see page 221).

dlepower per square centimeter. One lambert equals 1000 millilamberts, equals 296 candlepower per square foot, equals 2.054 candlepower per square inch, equals 0.318 candlepower per square centimeter.

Distance has nothing to do with brightness—which means that no matter at what distance from a light source, or other bright object, an observer places himself, it will appear always of the same brightness. The explanation of this lies in the fact that while the total quantity of light entering the eye varies inversely as the square of the distance between the observer and the object, the area of the image formed by the object on the retina of the eye varies in like proportion, so the intensity of this image remains constant. In other words, the brightness of the retinal image is always the same.

Dive Eleven

Descent of William Beebe and Otis Barton in Bathysphere, June 19, 1930. 800 feet. 12:56 to 2:08 P.M.

Feet	*Stop*	*Start* P.M.	*Observations*
Surface		12:56	Flyingfish.
25	12:57		
50	12:58	1:00	Small transparent jellies. 40 or 50 small fishes in a school: pearly blue with clear yellow vertical bands. 6 or 8 small Pteropods.
100	1:01	1:02	
150		1:03	
200	1:04	1:06	Psenes again, same kind as in Dive 10. 20 Pteropods, very lovely, large, transparent jellies, 4 inches. Motion picture taken of Psenes.
250		1:07	Psenes in the distance.
300	1:08	1:09	Small Pteropods. Shrimps constantly seen. Pteropods at this depth look like silvery vibrating bubbles of air.
400	1:11	1:12	Faint luminescence seen for first time. Can see a big jelly go away at least 20 feet before it vanishes. Luminscent jellies. 2 big Firolas 15 inches long. String of salpa with about 30 brown bodies.
450		1:13	
470	1:14	1:15	
550		1:16	The usual jellyfish, Pteropods and shrimp.
600	1:17	1:18	Leptocephalus 6 inches. 5 fish, Seriola-like. 2 round fish with black spots. They look transparent.
650		1:18.5	School of 100 Pteropods, golden in electric light.
700	1:19	1:22	Jelly, 1 foot, apparently with luminescent food in its stomach. Swam past window.
750		1:23	Brightness of blue is astonishing when I look up. Downward it seems very black. Something around the bait. Very bright.
800	1:24	1:41	2 black fish 8 inches long going by. Rat-tailed: probably Idiacanthus. 2 long silver eel-like fish, probably Serrivomer. Fish and invertebrates go up and down the shaft of light like insects. 3 Myctophids with headlights. Diaphus. (Work with a mirror next time.) 2 more different Myctophids. The same three Myctophids with headlights. 20 Pteropods and 6 or 8 Argyropelecus altogether. 3 more Pteropods. Little twinkling lights in the distance all the time, pale greenish in color. Eels, 1 dark and 1 light. Big Argyropelecus coming. Looks like a worm head on. Eustomias-like fish 5 inches long. 30 Cyclothones, greyish white. Could see every movement. An amazing number of fish seen in seventeen minutes.
750		1:41.5	
700	1:42	1:43	
650		1:44	A dozen shrimps with luminous spots.
600	1:45	1:46	
550		1:48	
500	1:49	1:50	Temperature 69° at 1:50 P.M. Most beautiful blue of all at this depth. Lots of Pteropods, at least 50. The bell reflects full motion of the ship.
450		1:50.5	
400	1:51	1:56.5	2 Psenes 2 inches long. Pteropods.
350		1:57	10 brown jellies, Linuche.
300	1:58	1:58.5	
250		1:59	Psenes 3 inches long.
200	2:00	2:01.5	
150		2:02	
100	2:03	2:03.5	
75			Transparent jellies going past.
50	2:05	2:06	
25	2:06.5	2:07	
Surface		2:08	
On deck		2:09	

Position:
4¾ miles SW of Nonsuch.
32° 16′ 41″ N. Lat., 64° 41′ W. Long., at 1:00 P.M.

Traveling time:
Down—15 minutes.
Up—17 minutes.
Total average traveling time per 100 feet: 2 minutes.
Total average traveling time per 1 foot: 1:2 seconds.
Temperature: 500 feet, 69°, at 1:50 P.M.

Dive Twelve

Descent of William Beebe and Otis Barton in Bathysphere, June 19, 1930. 120 feet. 3:02 to 3:20 P.M.

Feet	*Stop*	*Start* P.M.	*Observations*
Surface		3:02.5	
20	3:03	3:03.5	
40		3:04	
50	3:04.5	3:09	
60			Salpa and jellyfish.
75	3:10	3:11	
100	3:11.5	3:12	
120	3:12.5	3:17	Parrot-fish, 3 species; 2 foot angel fish. Brain coral. Dozens or so of little blue fish 6 inches, Scarus caeruleus. See bottom plainly. Big moray, 4 feet. Largest angel fish ever seen, 2½ feet long. Huge sea plumes. Dark blue parrot-fish, with a broad, vertical, pale blue band.
110		3:18	
Surface		3:20	

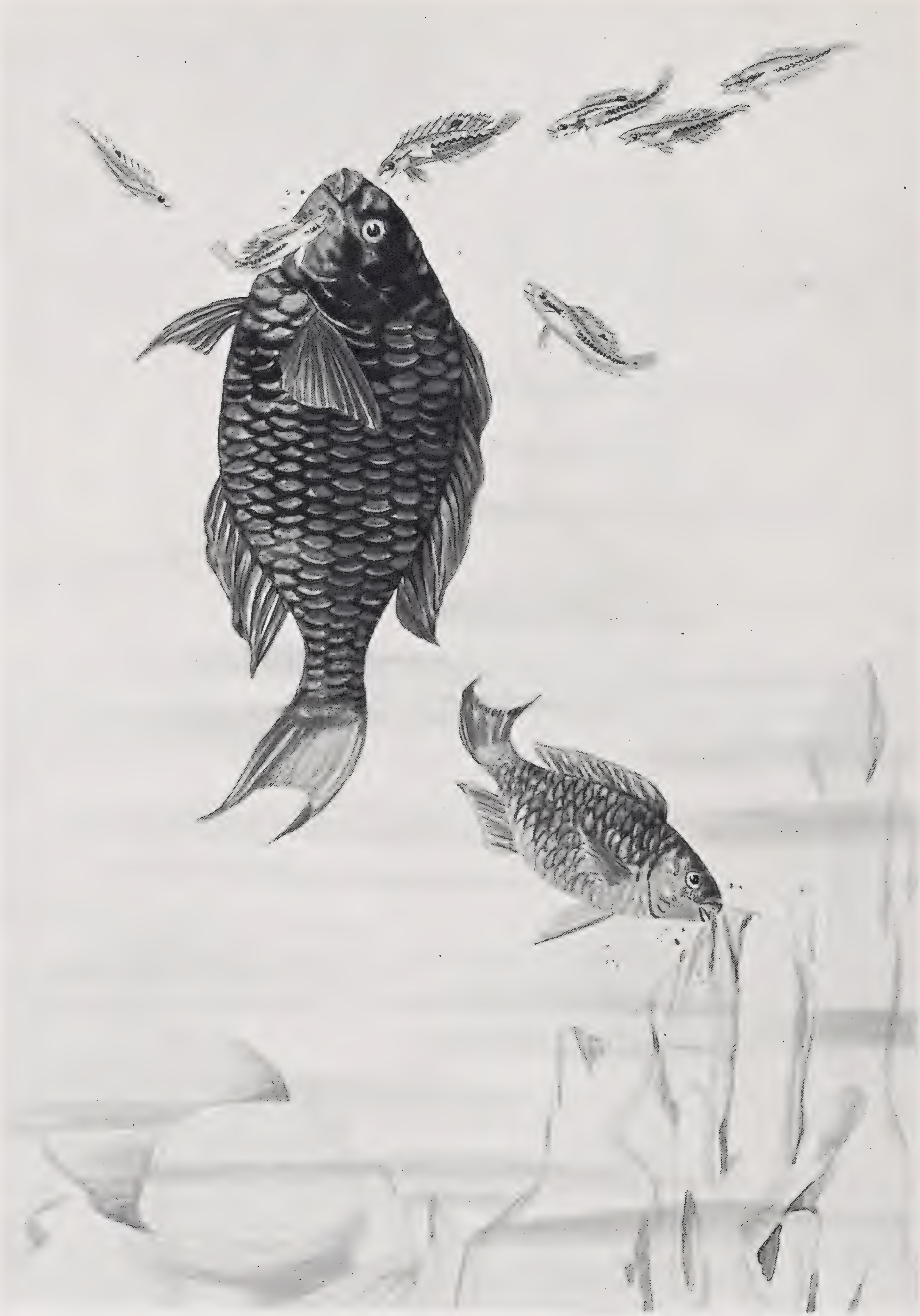
Position:
¾ miles South of Gurnet.
32° 19′ 30″ N. Lat., 64° 39′ 30″ W. Long., at 3:25 P.M.

Traveling time:
Down—3:5 minutes.
Up—3 minutes.

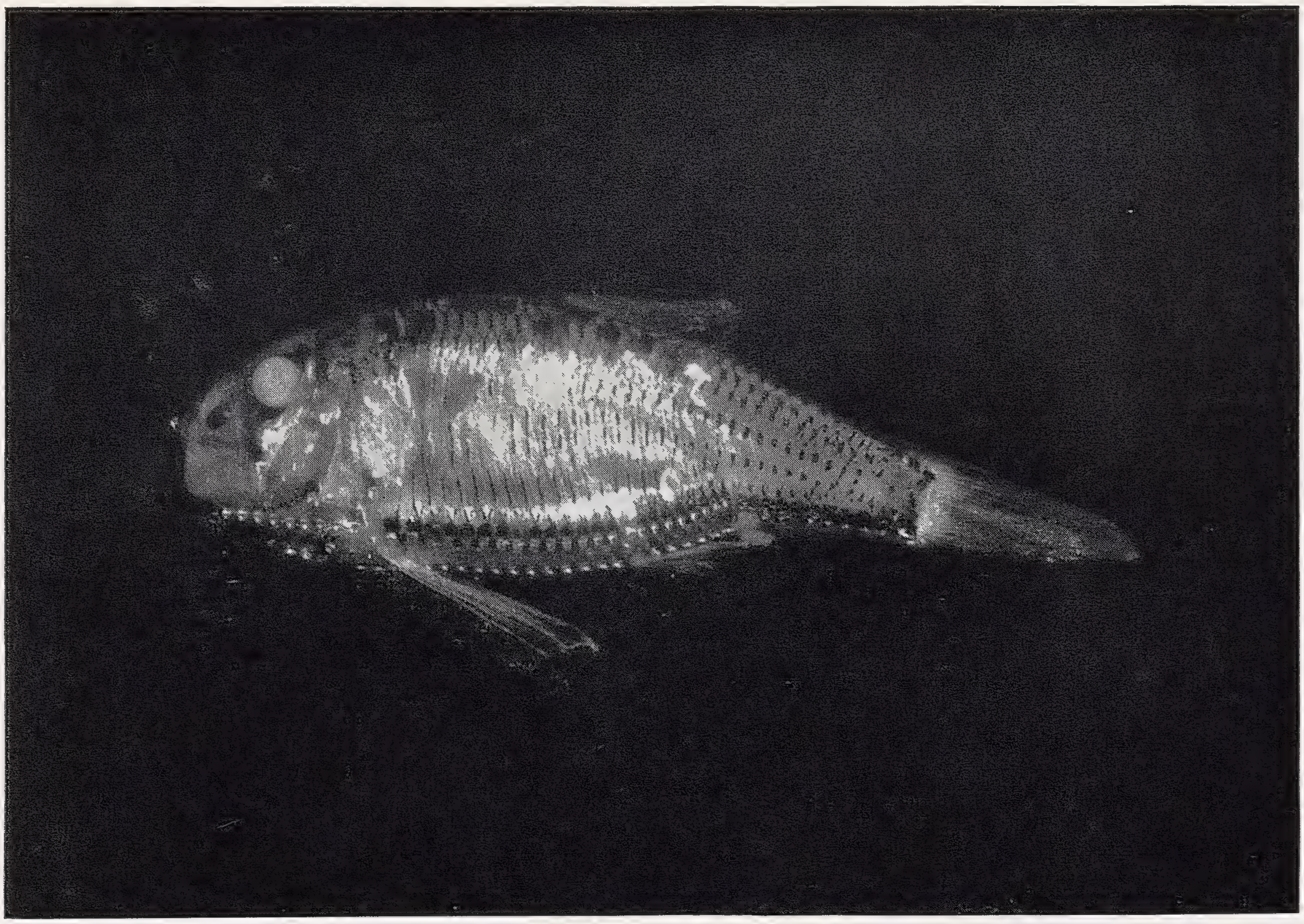
Dive Thirteen

Descent of William Beebe and Otis Barton in Bathysphere, June 19, 1930. 80 feet. 3:22 to 3:37 P.M.

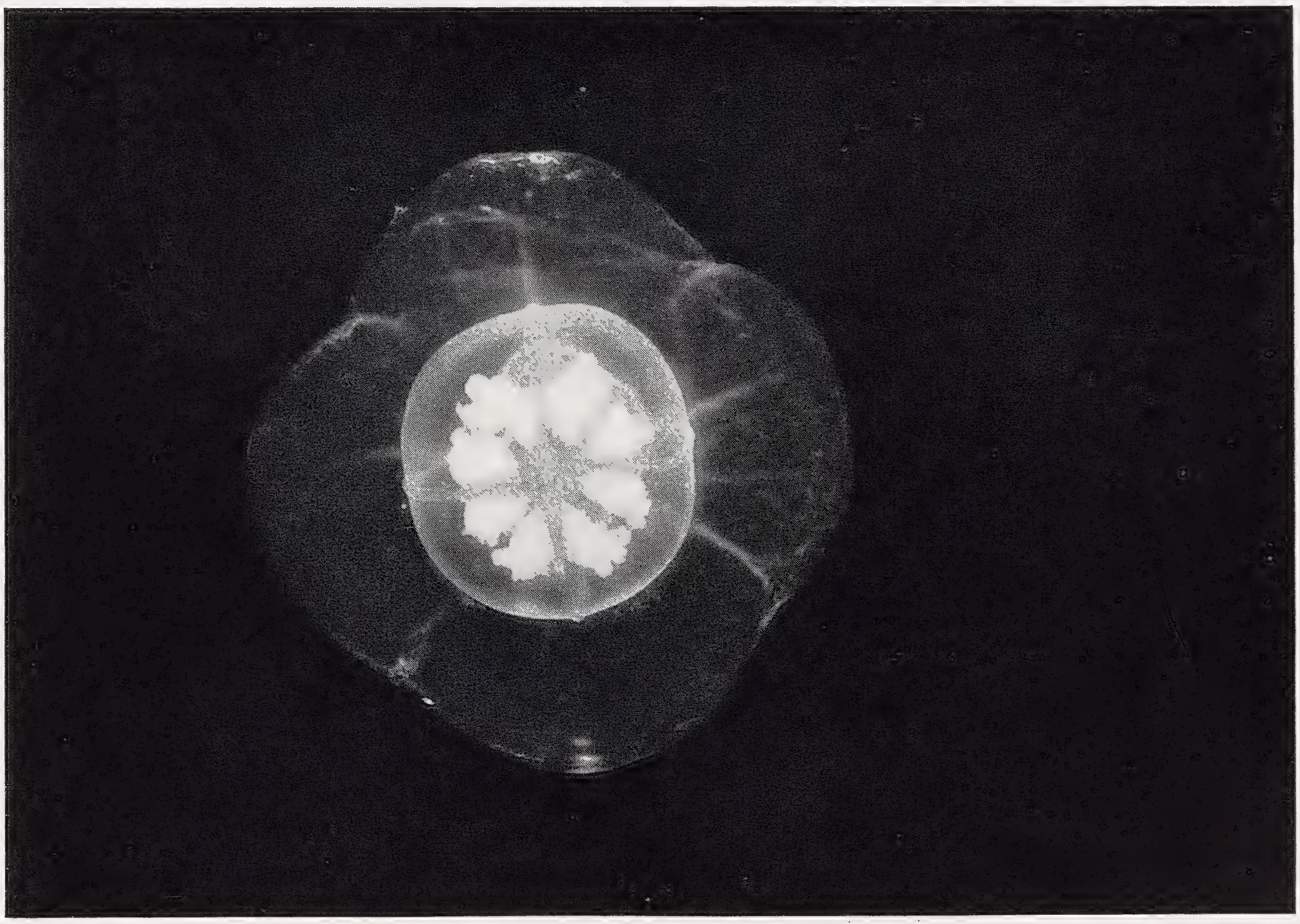
Feet	*Stop*	*Start* P.M.	*Observations*
Surface		3:22	
60	3:25	3:30	
70	3:31	3:35	



The green-toothed giant Parrot-fish balancing upright in mid-water while a school of Wrasse cleans its scales of bits of coral debris: A common reciprocal relationship between *Pseudoscarus guacamaia* and *Iridio bivittatus*.
Painted by E. M. Bostelmann.



The silvery *Ichthyococcus*, ablaze with lights, which is not uncommon in the deep sea. In form it stands midway between the bizarre-shaped Hatchet-fish and others of more normal appearance.



A tiny, glass and gold jelly from below the limits of light, as fragile as tissue, yet living in a pressure of 800 pounds to the square inch. Photographs by J. Connery.

Feet	*Stop*	*Start*	*Observations*
75	3:36	3:36.5	Bottom just appearing.
80	3:37		School of Kyphosus, 40 or 50. Moray eel 4 or 5 feet long. Aulostomus 4 feet. Almost desert-like. No vegetation. All rocks. Coral scattered here and there. Rocks have all been exposed.
70			Have seen a new fish. Cable lying on the bottom! Largest blue parrot fish, 3-4 feet long. Huge caverns and abysses.
Surface	3:38		

Position:

¾ miles South of Gurnet.

32° 19′ 30″ N. Lat., 64° 39′ 30″ W. Long., at 3:25 P.M.

Traveling time:

Down—10:5 minutes.

Up—1 minute.

Dive Fourteen

Descent of William Beebe and Otis Barton in Bathysphere, June 20, 1930. 350 feet. 9:21 to 9:51 A.M.

Feet	*Stop*	*Start*	*Observations*
		A.M.	
		8:10	"Ready" under tow.
		8:18	Castle Roads.
		8:24	Passed Gurnets Rock. Course, SSW to edge of deep. Moderate steady swell.
		8:45	Lights tested.
		8:50	Sounding 150 feet.
		9:00	Motor tested.
		9:02	Stopped towing.
		9:06	Sounding 170 feet.
		9:07	Door in place.
		9:10	Door fastened.
		9:13	Sounding 200 feet plus.
		9:17	Plug in.
		9:19	Bell over.
		9:20	Sounding 200 feet plus.
Surface		9:21	Under surface looks quilted. Bubbles three-fifths under surface. The windows are facing front. (Rudder appears to be working splendidly.) Waves look like little tucks from bottom.
20	9:22	9:24	Red is down to a narrow line. Nothing above 625. Half a dozen Linuche jellies.
50	9:25	9:26	Spectrum reading: A faint, brownish red line at 600.
75			"Ready for 100 feet." Two big fish passed at seventy-five feet.
100	9:27	9:28	Thinks he can see bottom faintly. (Soundings, none at 200.) Spectrum reading: No red at all. Thin line of orange. Violet has come down to 450 and has considerably overspread blue. Whole spectrum dimmer.
125	9:29	9:29.5	No radical change in spectrum; orange line a little thinner.
150	9:30	9:30.5	Is sun out? (Yes, but dimmed.) We are still facing forward as hooks are facing back.
175	9:31	9:31.5	Send to 200 feet. (No sounding 200.)
200	9:32	9:35	One inch jellies going past, transparent. Whole spectrum dimmed. Blue practically gone, violet overlaid it. Yellow is dirty yellow with just a little dirty fringe. Lower to 225, bottom not in sight. (Motor on at 10:25, light test O. K. Light turned off in bell.) "Ready for 225."
225		9:36	Small silvery fish 4 inches long. Lower to 250.
240			Small flock of sagitta.
250	9:37	9:38	(Waiting for stronger sun light.) Spectrum reading: Darkest part on edge of green and violet. Green the lightest part of the spectrum, going off into dark violet at other edge of spectrum. Yellow dirty. "Lower 25 feet more."
300	9:39	9:39.5	Take sounding, lower 25 feet more.
325		9:40	Leptocephalus went past. Lower to 350 feet.
350	9:40.5	9:42	Is tug pulling steadily ahead? (Tug parallel with coast and slightly in.) Light on in bell. Light off in bell. Raise.
325			Spectrum reading: Very dim, violet overshadowing green.
300		9:43	
250			Reading of color chart; corresponds exactly with spectrum.
200	9:45	9:45.5	Chart from beginning of red to yellow is brown.
150		9:47	No red yet. Reading on spectrum about 600.
100			Motor off.
50	9:48	9:50	Thin line of red brown just above 600. Regular jellies and little sagitta going by. No Pteropods. Facing ahead as all creatures are coming head on to them. Much easier to see.
25			Only a little red now. Growing rapidly. 650 reading.
Surface			650 jumped to 700 as we came out of water.
On deck		9:52	
Door off		10:00	

Bathysphere came up facing same way it went down, showing that rudder works. Plug off 9:54.

Traveling time:

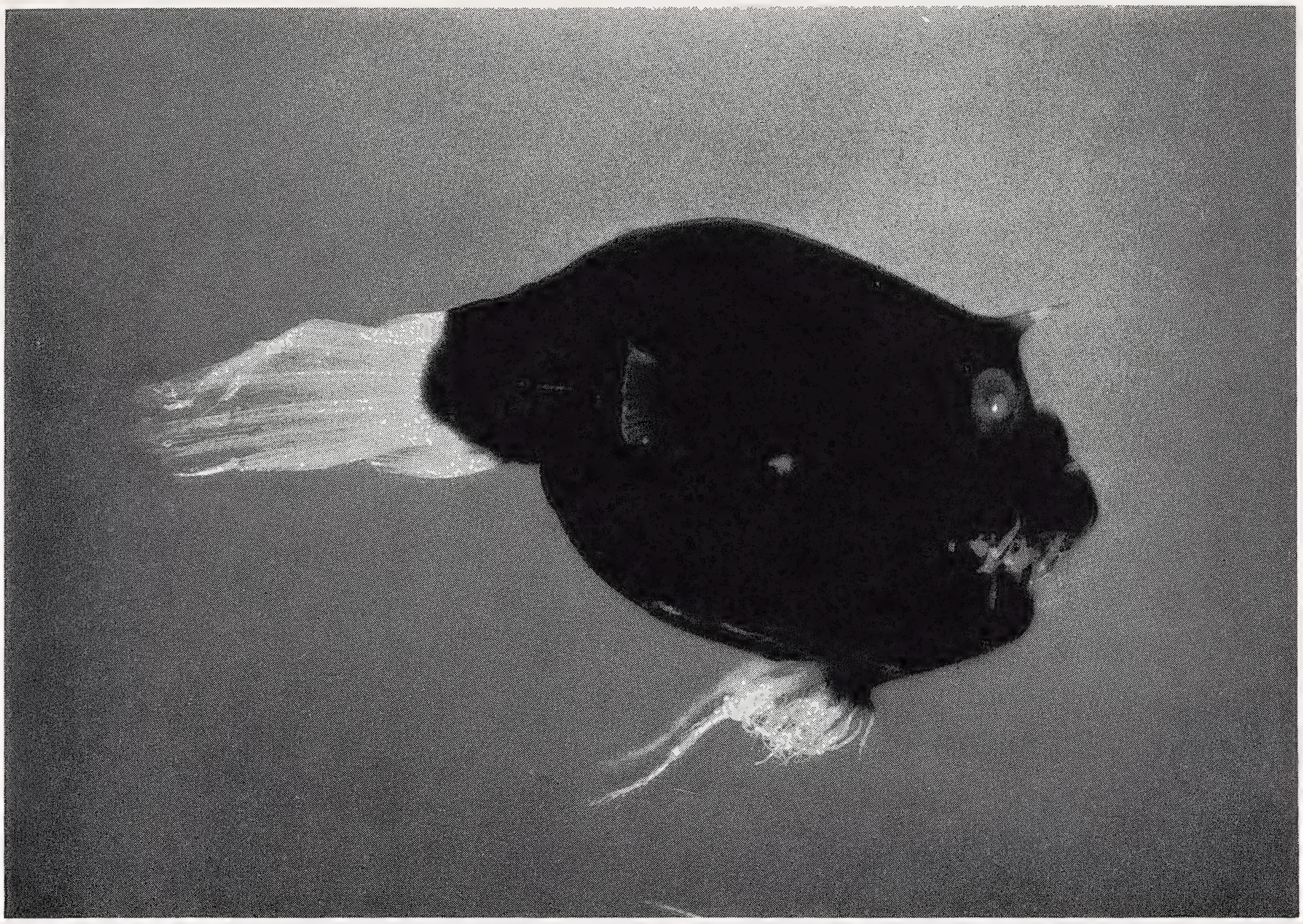
Down—9:5 minutes.

Up: 6:5 minutes.

Dive Fifteen

Descent of William Beebe and Otis Barton in Bathysphere, June 20, 1930. 210 feet. 10:21 to 11:05 A.M.

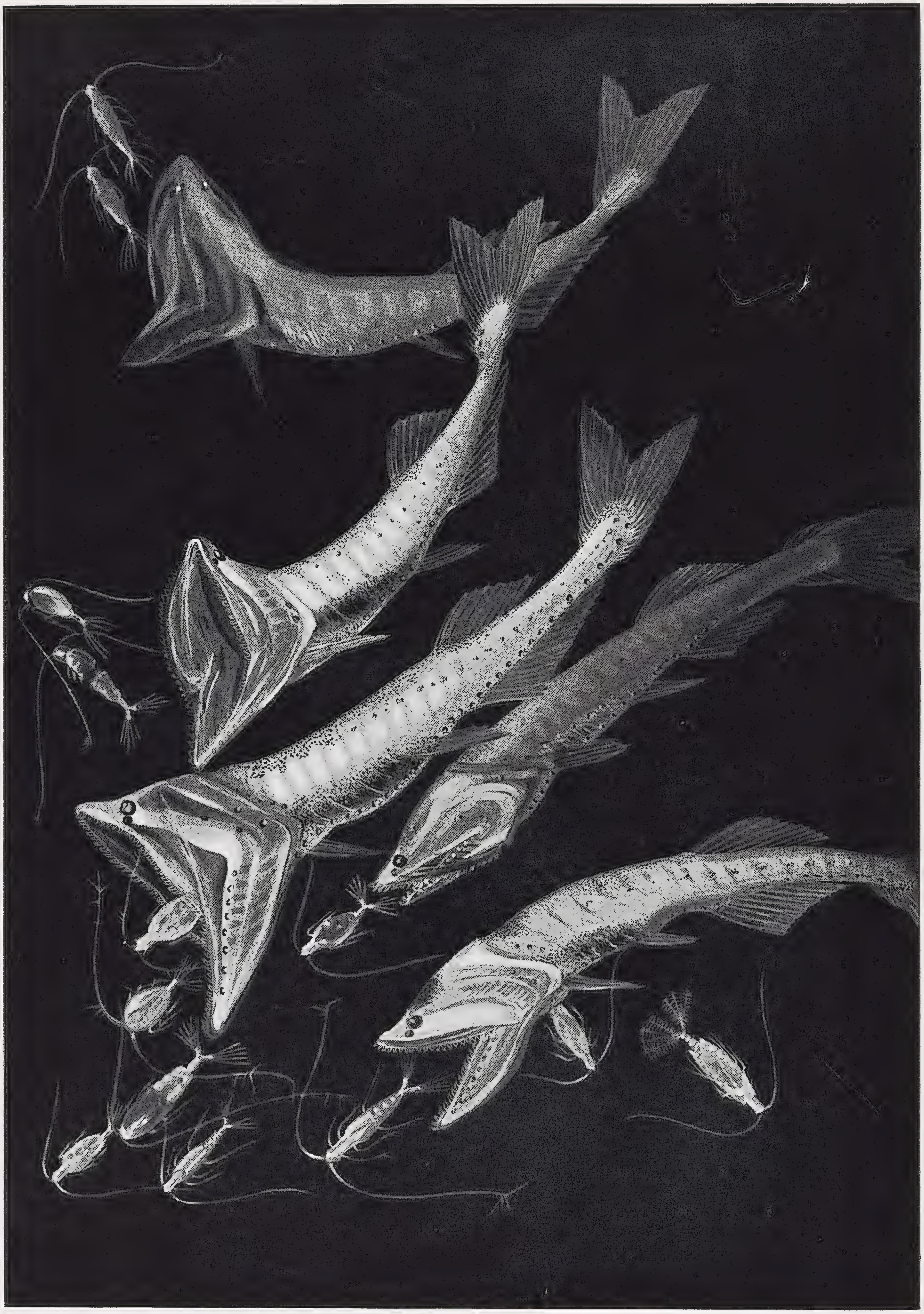
Feet	*Stop*	*Start*	*Observations*
		A.M.	
Surface		10:21	
10		10:21.5	Lower to 20 feet. (Sounding 55 ft.)
20		10:22	Can just see bottom. Lower another ten feet.
30	10:23	10:37	(Big hole ahead.) Otis saw Holothurian. Bottom looks rather dead. Moving obliquely forward to left. (10:26 sounding 50 feet.) Swinging at an arc of about 30 degrees. (10:27 sounding 75 feet.) (Sounding made in hole.) Many big dark blue parrot fish dominant fish here. Big Aulostoma three feet long. General bottom vegetation like that along shore, more covered with layers of sand. (10:30 sounding 55 feet.) (Boat rolling.) School of big Kyphosus about eighteen inches to two and a half feet long. About twenty in number. (10:31 sounding 50 feet.) Small wrasse with dark strips on them. (Wind increasing a bit.)



A black sea dragon *(Linophryne)* from 600 fathoms, with white tail and barbel and luminous teeth.

Feet	*Stop*	*Start*	*Observations*
			(10:35 sun under, casting no shadow.) (10:36.) Thousands of parrot-fish all going obliquely downward. All pale blue with orange around mouth. Looks pale but probably cerulean blue. Six inches to two feet long. (10:36 sounding 75 feet.) Seem to be moving obliquely to current. Lower up to 50 feet.
50	10:38	10:42	(10:38 sounding 95 feet.) (10:40.) Nothing but deep orange at 610.
55			(10:41 sounding 100 feet.) Lower to 75 feet.
75	10:42.5	10:43	Just picked up bottom very faintly. Sandy desert, very dim. (10:42 sounding 105 feet.) Ten more feet.
85	10:43.5	10:45	Very flat bottom sandy desert. (10:43.) Big fish but too dim to identify. (10:45 sounding 140 feet.) Down to 100 feet.
100	10:46	10:47	(10:46.) (Sounding 145 feet.) Lower to 110 feet.
110		10:47.5	Ten more feet. (10:48 sounding 160 feet.) No bottom seen.
120	10:48	10:49	Twenty more feet.
140	10:49.5	10:50	Same kind of sandy bottom. (10:50 sounding 175 feet.) Down ten feet.
150	10:50.5	10:51	We can see bottom dropping off, looks flat, must be about twenty-five feet above. (Sounding 175 feet.) Ten more feet.
160	10:52	10:52.5	Ten more feet.
170	10:53	10:53.5	(10:30 sounding 195 feet.) Ten more feet.
180	10:54	10:54.5	(10:56 sounding 230 feet.) Ten more feet.
190	10:54.75	10:56	(Motor on, lights on at 10:55. Lights turned off in bell.) Send to 200 feet.
200	10:56.5	10:57	Ten more feet without clamp.
210	10:58	10:58.5	Put on clamp. Hold. No clamp. Pull to surface.
190		10:59	
180		10:59.5	
160			Hold at 50 feet.
140		11:00	
120		11:00.25	
100		11:01	
85		11:01.5	
75		11:01.75	
50	11:02	11:03	Spectrum reading: violet goes to 450, extends way over blue, green brightest color. Nothing but deep orange 625. (11:02.)
25	11:03	11:04	To 650. Orange, and not red, spreads to 650. On color chart: numbers 1, 2, 3, are dark brown, number 4 a yellow brown. All the rest seem to be normal. Raise to deck. 660 nothing but orange three feet under surface. Extends to almost 700. Dull brownish red three feet under.
Surface		11:04.5	
On deck		11:05.5	

Traveling time:
Down—24 minutes.
Up—4 minutes.



A school of Cyclothones pursuing their prey. These are the most abundant of all deep-sea fish, and we sometimes take several hundred in one net.
Painted by E. M. Bostelmann.

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New York Zoological Society

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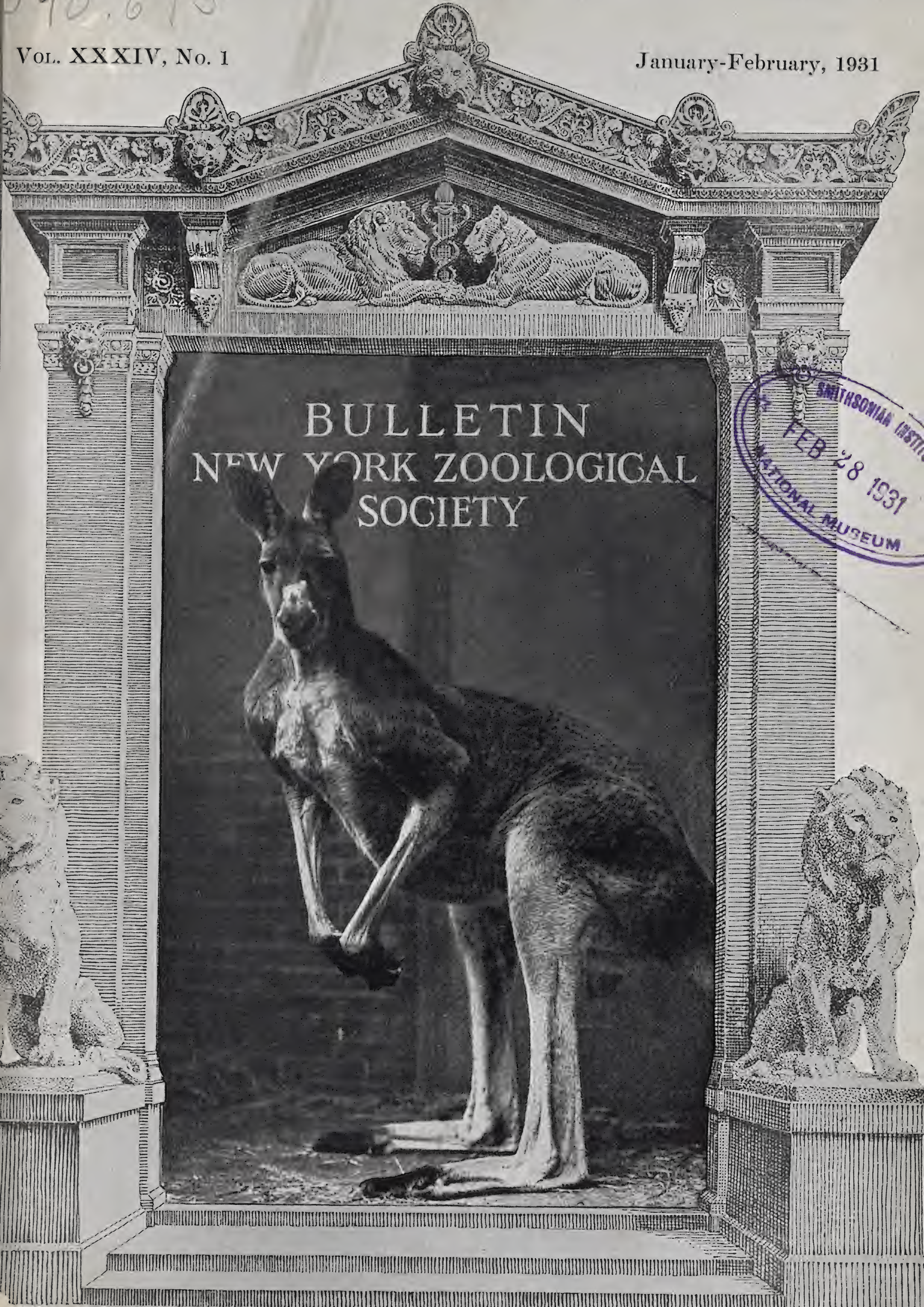

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BULLETIN

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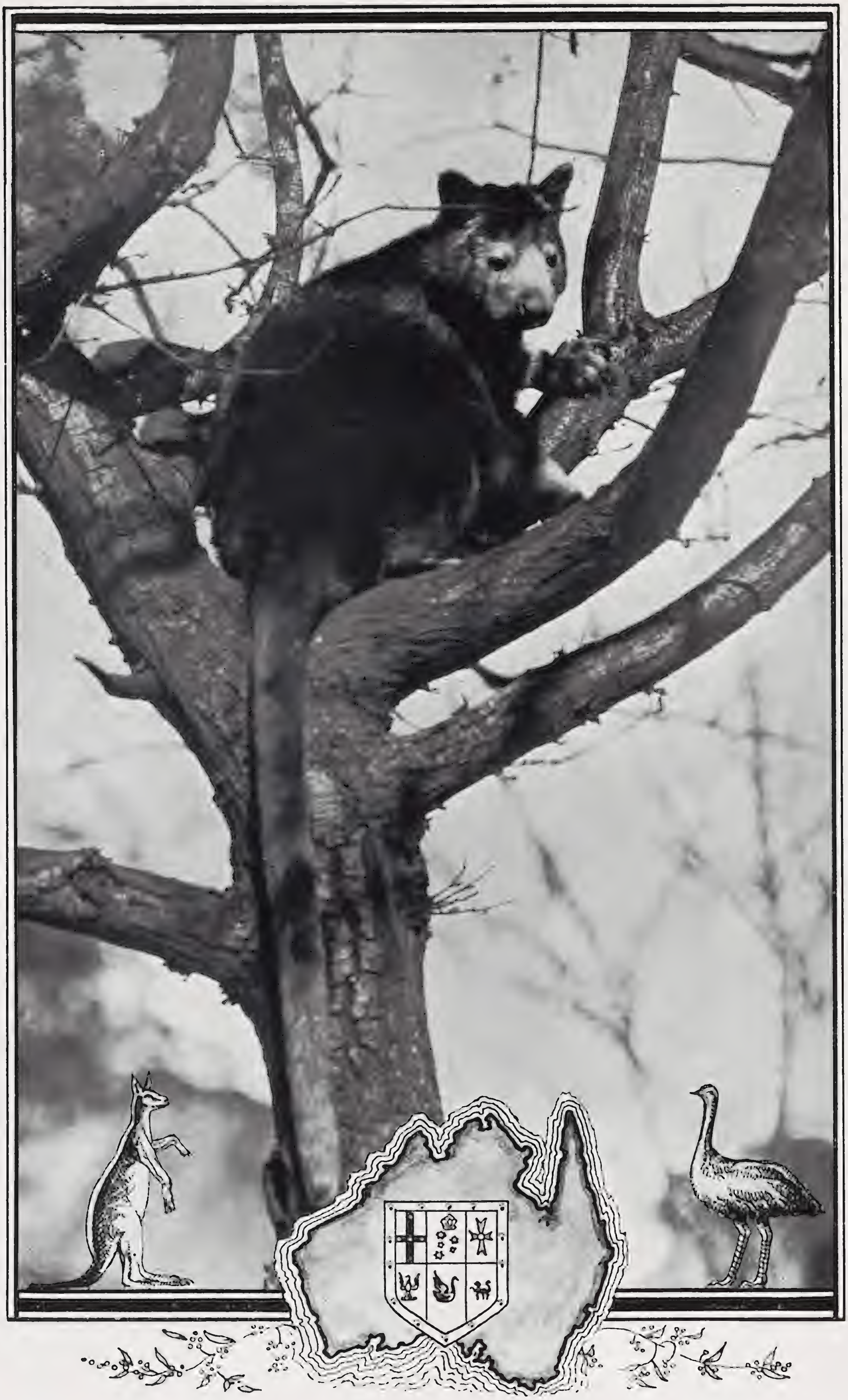

Bennett's tree-kangaroo *D. bennettianus*, in a tree, about twenty-five feet from the ground. From a photograph by the late W. H. D. Le Souef.

BULLETIN
NEW YORK ZOOLOGICAL SOCIETY

Published by the New York Zoological Society

Vol. XXXIV January-February, 1931 No. 1

Kangaroos and Their Kin*

Australia's National Animals in the Wilds and Captivity.

Charles Barrett, C.M.Z.S.
President of the Field Naturalists' Club of Victoria

Illustrations from photographs by the author taken in Australia, and from the collections of the New York Zoological Society by Elwin R. Sanborn.

AUSTRALIA still is the "Land of the Kangaroo." Though many millions have been slain for their pelts and persecution is almost unceasing, kangaroos and wallabies occur abundantly over wide areas of our island-continent. In Victoria, smallest of the commonwealth states, excepting Tasmania, kangaroos are increasing, and only this year "drives" were carried out, to thin their ranks, in several districts. Protection proved to have definite "survival value": before the game laws guarded them, kangaroos were becoming fewer every year in Victoria.

Other states, much larger than Victoria, allow kangaroos to be hunted all through the year; but eventually will be compelled to protect them, at least to limit the hunting season—else lose our national animals as familiar objects of open forest country and the plains. At present, happily, none of the large species is in danger of extinction, though some of the smaller forms (wallabies), are becoming scarcer.

It is one hundred and sixty years since the first kangaroo was seen by white men. The record of a remarkable discovery is given in the original account of Captain Cook's voyage, during which he chartered the east coast of this country and made it a British possession. Cook was the real founder of Australia; and was it not fitting that our world-famous mammal should by him have been discovered?

Not the great navigator himself, but one of his men first sighted a kangaroo. It was on a winter's day—June 22nd, 1770. A party from the *Endeavor* had been sent into the bush to shoot pigeons, as delicate food for the sick on Captain Cook's staunch little vessel. They discovered many Indian (sic) houses, the narrative states, and a fine stream of fresh water—and the kangaroo! Returning, they reported having seen "an animal . . . as long as a greyhound, of a slender make, of a mouse color, and extremely swift." Soon afterwards the Captain himself, and several others, including (Sir) Joseph Banks, the botanist, had the good fortune to see the strange animal. Eventually a specimen was shot. Since then millions have fallen to the gun, or other weapons.

The destruction of these marsupials has been encouraged by Governments placing a price on their heads. In twenty-five years (1877 to 1902) the Queensland Government, it is recorded, paid for the scalps of nearly seven and a half million kangaroos and wallabies! The tally for six months only, on one station (ranch) was 60,000.

There has been no truce in later years. Vast numbers of kangaroos and wallabies are killed

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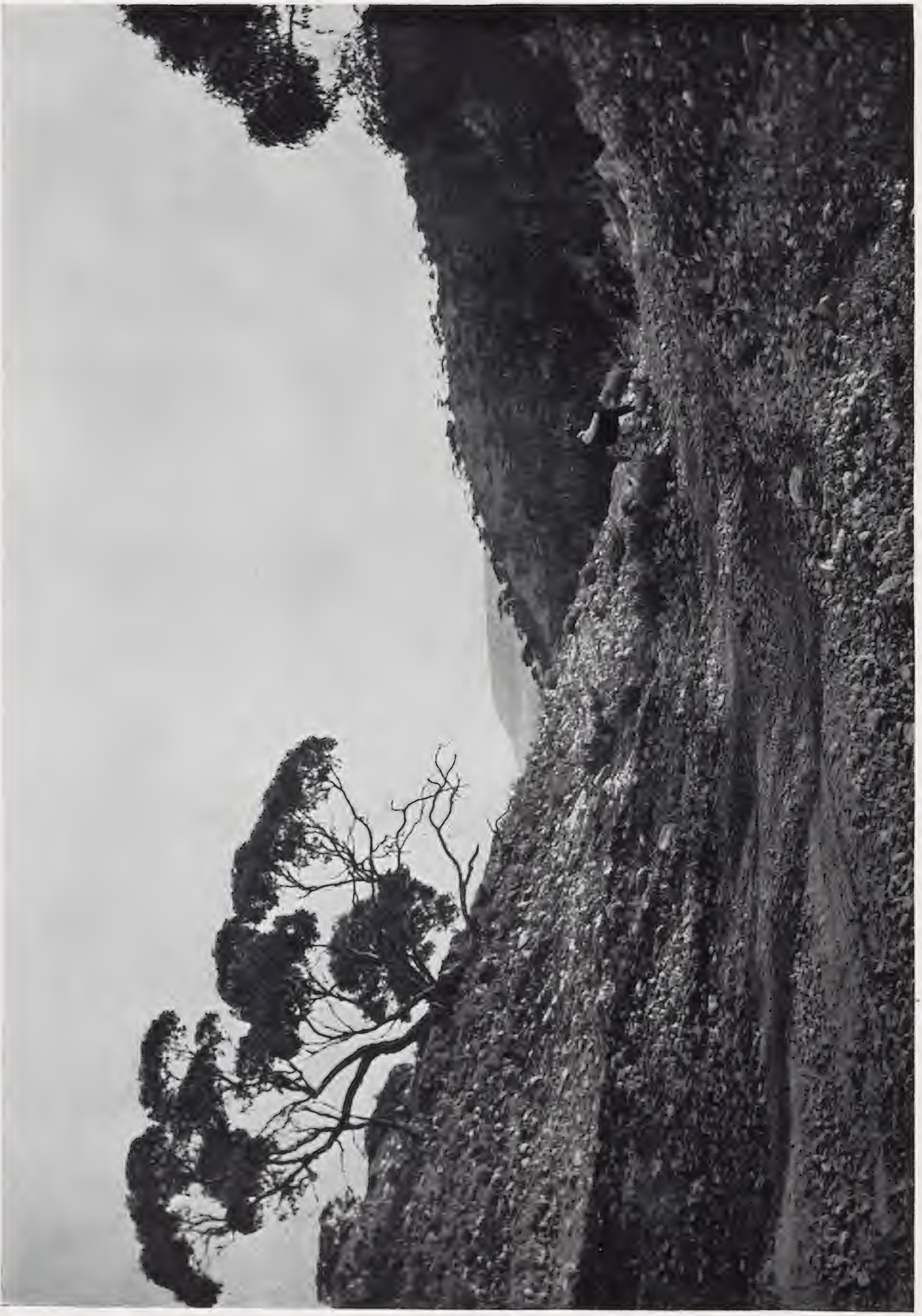
* Scientific nomenclature has been left to the discretion of the Author.—Ed.



Gap leading through limestone cliffs two hundred feet or more in height, to the coastal plains in south-western Australia. This is the habitat of kangaroos, *M. robustus woodwardi*, and the black-gloved wallaby *M. irma*. From a photograph by Charles Barrett.

annually by the pelt hunters. It is ruthless slaughter for gain, and, although conservation is urged by naturalists and nature lovers, it is justified, not on the score of commerce only, but for the reason that the grass-eating marsupials are competitors of sheep and cattle for natural food supplies, and they raid cultivation areas when the crops are young. Thus pastoralist and farmer have ever been leaders in the endless campaign against the kangaroos, and some of their smaller cousins, the wallabies. It has been, in all states, (Victoria excepted, in recent years) a war of extermination. Fortunately, some pastoralists give a measure of protection to the kangaroos on their wide holdings of the country. Besides, there are large reserves, sanctuary for all the Australian animals that frequent them. Conservationists do not despair of saving kangaroo and wallaby for posterity, though inevitably, as closer settlement spreads over the vast station areas, native animal life must steadily decrease.

Results of Destruction:—Those who hold a brief for the marsupials claim that wholesale destruction of kangaroos and wallabies has not achieved its main object. I quote from a standard work, "The Animals of Australia," by Dr. A. H. S. Lucas and the late W. H. D. Le Souef (former Director of Melbourne Zoological Gardens), the following:

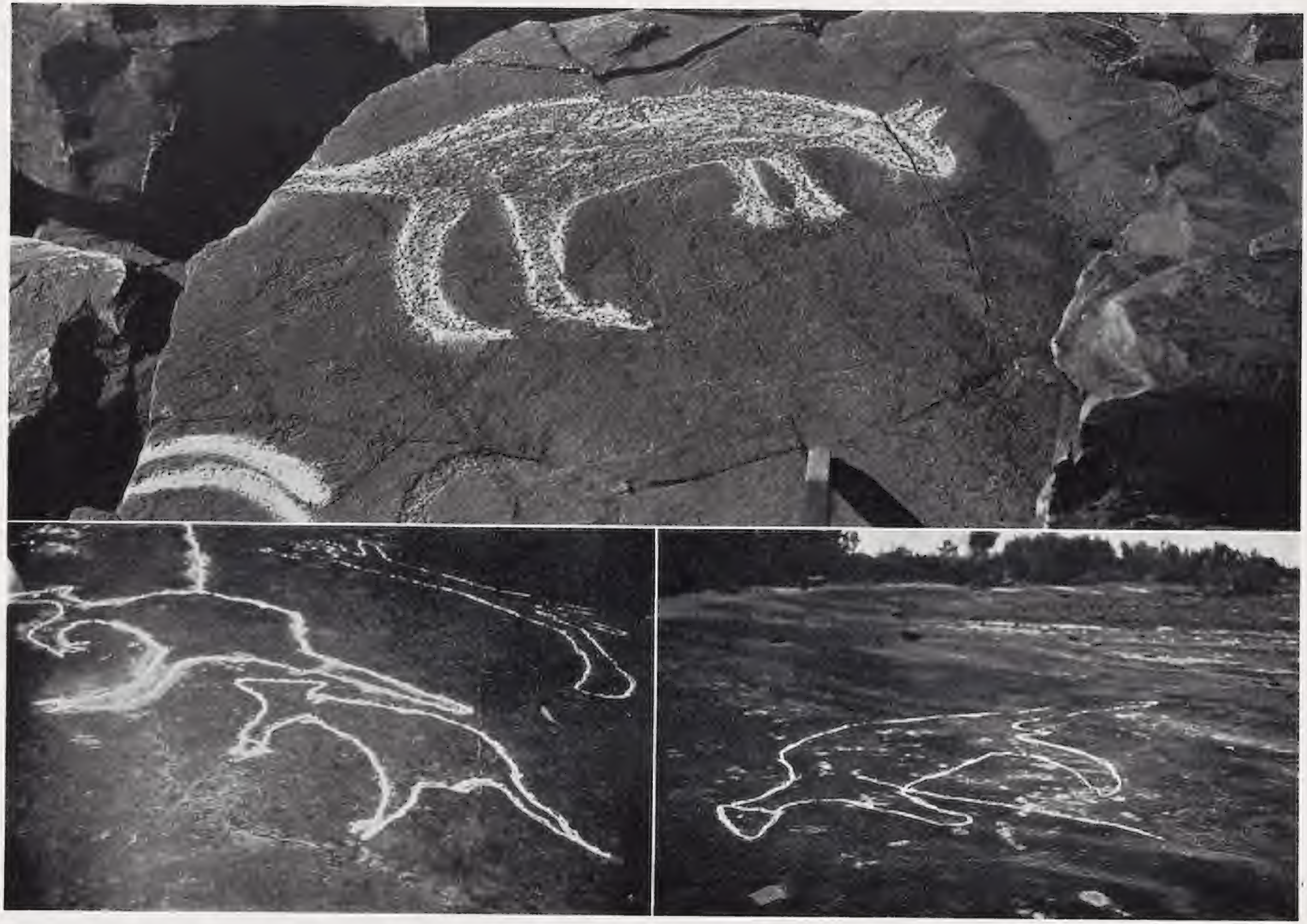
"In many districts the slaughter of their natural prey has turned the attention of the dingo to the sheep, and when once a dingo has tasted sheep he is henceforth contemptuous of kangaroo. Another evil has been ascribed in Queensland to the destruction of kangaroos. They were wont in past times to crop down the grass which grew in and around the patches of scrub where the sheep had not as yet penetrated. Now the grass grows and withers, and thus affords tinder for serious bush fires."

Dingoes (*Canis dingo*), the wild dogs of Australia, hunt in packs, alone, or in pairs, and are notorious sheep-killers. They take heavy toll of the flocks, and have no human friends, excepting the aborigines, who domesticate these "warrigals." In the inland areas, where human habitations may be fifty miles apart, dingoes abound. So numerous are they, in parts of Western Australia, that trappers are "in clover." One man, whose camp I visited a few months ago, told me that his average earnings amount to £15 (75 dollars) weekly; while occasionally he made five times as much. The "bounty" paid is £2 (10 dollars) for each "kill." Scalps and tails are the proof required before payment. Dingoes still prey upon marsupials, where they cannot get sheep; but undoubtedly man's war against kangaroos has tended to make the wild dog a sheep-killer.

The aborigines, of course, for many centuries, were enemies of the kangaroos and their kin; and still are in the central and northern portions of Australia. But, from the greater part of the continent the native tribes have disappeared, or are represented by a few scores or hundreds of more or less civilized blacks, mostly on mission stations or in reserves for aborigines. Many of these people have never hunted the kangaroo; some know less of its ways than does the city-business man, who, with a taste for natural history, spends his holidays out in the wilds.

The aborigines, nowadays, hardly count, excepting in the unsettled and "undiscovered" region, as enemies of the kangaroo. And even when the land was solely theirs, before the white man came, the blacks were no great menace to marsupial life: they were not sufficiently numerous, with all their hunting, to check the increase that nature ordained. Kangaroos and wallabies swarmed on the grass-plains and in open forest regions and, according to their species, in other classes of country. True, certain kinds, now rare, may never have been very abundant; but those with which we are most familiar, doubtless existed in countless numbers long ago, where now there are a few thousands or hundreds only.

The records of the rocks show that from the "Dream Time," as Arunta natives term the era of their legendary ancestors, the kangaroo has been associated with aboriginal life. One of the many "totem" animals, the kangaroo is forbidden as food to those tribesmen whose totem it is. It is figured in primitive "art galleries," either painted in white (pipeclay) or red ochre, or carved in the living rock of caves and shelters. Many of these portraits of *Macropus* have I seen: some crude as a child's chalk drawing on the nursery floor; others, though only in outline, nearer to nature than are the kangaroos painted in our studios!



Aboriginal rock-carvings. *Upper*. This petroglyph at Mootwingee, New South Wales, is famous for its antiquity. It is supposed to have been executed several thousand years past. The two white forms in the lower left are boomerangs, an interesting aboriginal weapon of strange power. Photograph by Charles Barrett. *Lower left*. Another carving depicting a kangaroo with a spear in its back. Also a smaller kangaroo and a deity. Duffey's Forest, New South Wales. *Lower right*. Rock carving of a kangaroo depicting that it has been speared by an aborigine. The carvings have been chalked to aid photographic delineation. From photographs by B. L. Hornshaw.

Some of the rock-carvings are fine examples of "pecking," a very ancient craft, or art. The lonely, rugged Mootwingee Range, in north-western New South Wales, was for centuries frequented by the blacks, maybe for ten thousand years. They have all gone now, and the gorge, where they feasted and carved figures and symbols on the rocks, is guarded by the white man's law as a reserve because of the art they expressed there.

When I was at Mootwingee, kangaroos often came near to the camp, just below the rock-holes that hold water even during a drought. These natural reservoirs, in an arid region, attracted both birds and marsupials; and the blacks could live at Mootwingee when, for miles around, the country was waterless and sere, and almost gameless. It was unsafe, in those far off days, for a kangaroo to appear "within cooee," as we say, of any camp-site! But then the animals were numerous; now they are few in the ranges.

There are innumerable pictures in that gallery, formed by nature, and decorated by primitive man. Flat and sloping rock-faces are covered in carvings; while a great high and shallow cave, which was used by the blacks as a shelter, has its walls flaked with "red hands" and other paintings, one being in the form of a huge serpent. On the rock by a pool are emu feet, thought to be the oldest petroglyphs in the romantic gorge. Their age has been estimated at from five to ten thousand years. Very ancient they certainly are.

In myth and legend the kangaroo has its place, but, strangely, one less prominent than that held by the emu, and some other birds, and by mammals less closely associated with aboriginal life than the kangaroo has ever been. Consider how many of the blacks' needs have been supplied by the kangaroo. Tribes that effected "dress," made their one-piece garments mainly of kangaroo skins. Universally, the flesh was native food; while use was made of leg bones for various purposes: needles were fashioned from them, for instance, and tendons off the hind-legs and the tail utilized as "thread." Some tribes wear kangaroo bone nose-ornaments. Necklaces were made out of the incisor teeth of kangaroos, attached to long strips of the animal's skin, dressed until pliant as a worn kid-glove. The tail-sinews were used to sew the teeth to the leather. Its importance as a totem animal should be remembered, too. One would expect a big crop of kangaroo legends and myths. Of course, there are many, but fewer than might have been invented by the "tellers of legendary tales."

The origin of the very word, kangaroo, is uncertain. You will not find it in vocabularies of aboriginal dialects, though "koongaroo" and "kungara" are native words. Captain Cook obtained it from the Endeavor River tribe; or some word of very similar sound. "Kangaroo" was a word unknown to the blacks in the "type" locality of the first kangaroo seen by white men, when an explorer visited it fifty years after Captain Cook. The term in use was "menua." The red kangaroo was known as "purra" by the members of one tribe; and the grey kangaroo, as "kaiimer." A list of kangaroo words from the vocabularies would be long. It has been suggested that the tribal name of the first-comers to Australia began with the sound "koo," and that, finding no human inhabitants, they "whimsically called the kangaroo, which they saw standing erect like themselves, by their own tribal name"!

How the kangaroo got its tail is the theme of one myth—of an extinct Victorian tribe. Mirram (the kangaroo) and Warreen (the wombat), once upon a time were men, and lived in the same place; the latter had a good camp; the former had none. After a great rainfall, Warreen was snug by the fire in his bark shelter, while Mirram shivered outside, his fire extinguished. The wombat would not allow his friend even a corner of the camp. Well, Mirram lost patience, flattened Warreen's head with a stone, and said "You shall live in dark-holes"—the wombat's dwelling is a burrow. One day, Warreen threw his spear and it stuck fast in the lower end of Mirram's backbone. "It will be a tail for you," said the wombat, and you shall have to use it when you run." And that's how the kangaroo got his tail.

He makes good use of it, too! But not in the manner believed by those who have never watched kangaroos closely, or are familiar with them only as captive animals. The broad-based, powerful organ is used as a third leg, a support when resting. When the kangaroo hops, with body inclining forward, its tail does not "beat"

Agile wallaby *M. agilis* in the Zoological Gardens, Melbourne, Australia.
From a photograph by Charles Barrett.

the ground, but acts as a balance: a tailless kangaroo would topple over "on the hop," instead of being nicely balanced on its hind legs.

Kangaroos are splendid jumpers, but when traveling at a leisurely pace, cover only about four or five feet in a hop. The faster they go the longer the hop, with return to short ones if the ground offers obstacles. Records vary, but, at its best, a fullgrown kangaroo might cover eight or nine yards with one hop. Often I have watched kangaroos in the wilds, and wished that I could measure their "steps," as they fled across the plain or through the timber. There is no more wonderful picture of wild life at home, in Australia, than a mob of kangaroos hopping from what may be danger. I have never hunted them. That is not sport, though kangarooing on horseback, with dogs trained to the hunt, is still described as "sport" by many Australians. Pursuit in motor-cars also is favored by some shooting men. Well, I am no sportsman for I hunt only with fieldglass and camera. A living animal to me is worth a hundred dead ones of its kind, whether it be furred or feathered.

Kangaroos and wallabies, generally speaking, thrive in captivity, if properly fed and given ample room to move about, in their own peculiar manner. It is cruel to keep them in small enclosures. Many I have seen, pets of the family, had the freedom of big yards, or even a paddock. Others were so content with a tame life, that they were allowed to go where they pleased. One old kangaroo, was a familiar figure in a little township or village. He visited the neighbors! Again, kangaroos may be kept in a wire-netted run, many yards in length and two or three hops wide. They do not appear to be unhappy in such quarters.

On some of the sheep stations, kangaroos are allowed to live in reasonable numbers; a "drive" being held occasionally to prevent over population. The animals are not necessarily killed, though the drive, in some cases, is, frankly, slaughter. Look at the pleasanter picture.

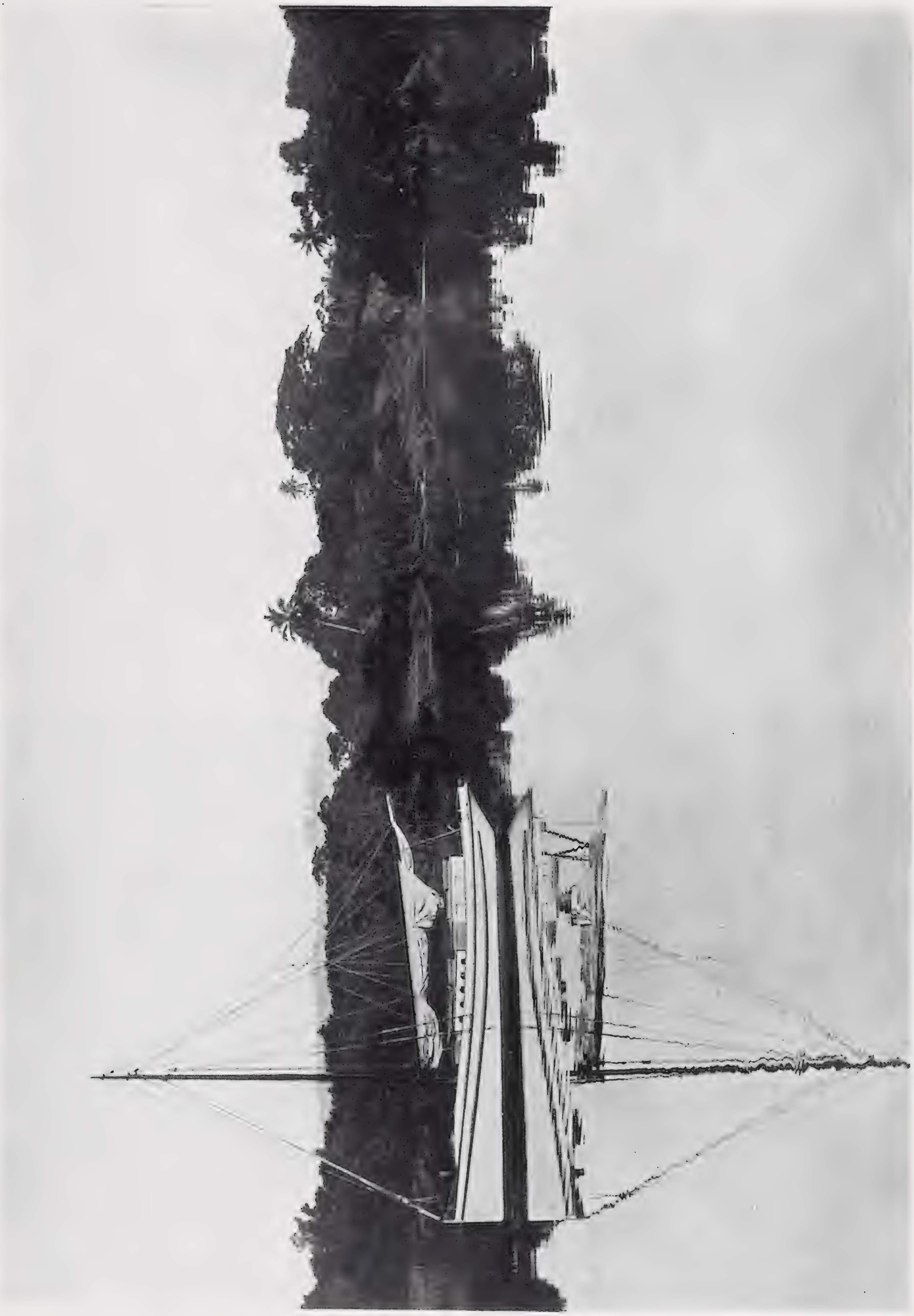
This year, two kangaroo drives were held in Western Victoria, by authority of the Fisheries & Game Department. The animals were shepherded into a high-fenced "corral," and captured without being injured. They were sent to the Zoological Garden, which needs kangaroos for exchange with Zoos in America and other countries. The demand is pretty constant; and for our marsupials we receive bears and buffaloes, deer, birds, and other creatures—at current exchange rates.

During a drive, kangaroos may display their powers of leaping. They jump at the high fences, and sometimes get over. Hunted, a kangaroo has taken a fence nine feet in height, without touching the rail. This is exceptional, possibly a record; for many kangaroos, unfortunately, break their legs in attempting paddock fences on the stations. Six feet is a good jump for a kangaroo, and often enough a fence of that height baffles them. Those crippled in trying to jump wire-fences, die slowly of hunger, or are put out of their misery by the boundary rider, who has also to kill disabled emus. The fences claim many victims, and emus predominate.

Notable among the squatter friends of the kangaroo was the late Mr. H. L. White, of "Belltrees" Station, Scone, New South Wales. He was a rich and generous patron of natural history, and himself a fine naturalist, specializing in birds. His collection of Australian birds' eggs, the most valuable and complete in the world, was bequeathed to the National Museum, Melbourne. Mr. White, in a fifteen acre paddock, kept about thirty kangaroos and a few wallabies. He began, many years ago, by having tame kangaroos about the homestead, allowing them full liberty. But visiting dogs killed so many, that an acre was enclosed with wire-netting, for a grey kangaroo and some wallaroos. Finally, the big paddock adjoining the house-garden, was surrounded by a six-foot fence of netting and barbed wire. When Mr. White wrote the story of his pets (for the "Australian Zoologist") his stock consisted of fifteen wallaroos (*Macropus robustus*), ten grey kangaroos (*M. giganteus*), and five red kangaroos (*M. rufus*). All of them bred freely; wallaroos more than the other kinds, so that it was difficult to keep their numbers within reasonable limits. However, the population of the paddock was reduced by liberating some of the "captives." It was not easily done, for they declined to go through the open gate when driven, instead, in their excitement, dashing into the fence. They would "run or jump over both man and horse attempting to stop or to turn them."

The first grey kangaroo kept by Mr. White became famous. He was an immense animal,

Bennett's wallaby *M. bennettianus* in the Zoological Gardens, Melbourne, Australia.
From a photograph by Charles Barrett.



A scene on the Daintree River, North Queensland. In the mountains where this river has its source is the habitat of the tree kangaroos. From a photograph by Charles Barrett.

named "Ben," and a wonderful fighter. He had a very bad temper, and was dangerous. "Upon several occasions," his owner wrote," he broke the wire netting by kicking it when teased, and he half-killed a couple of men who ventured into his domain; he was eventually destroyed." "Ben" liked a bath; and, before he became savage, would approach when the gardener was watering. When the hose was played upon him, as he stood against the wire-netting, "Ben" would "turn round slowly, lifting his arms meanwhile, so that every portion of his body got a thorough wetting."

Zoo Director's Records:—No one has a wider knowledge of kangaroos in captivity than my friend, Mr. Andrew Wilkie, Director of Melbourne Zoological Gardens. He has completed over fifty years' service at the Zoo, having started as a youth. For many years he was foreman, succeeding to the directorship on the death of Mr. LeSouef.

Necrosis, Mr. Wilkie states, is the chief cause of mortality among captive kangaroos, but there is no evidence that it is at all prevalent in their wild state. Soon after they are captured, the complaint may develop; or it may not do so until months later. Healthy animals shipped to Great Britain, died soon after arrival, from necrosis.

Again, from no apparent cause, other than fretting for freedom, death may occur. Thus, more than a score of kangaroos captured in a drive, died within a few months. Post mortems revealed neither disease nor ill-nourishment—the victims had fed normally. But, many of the marsupials, happily, escape disease and do not suffer from longing for the wilds. They settle down in the paddock, and become quite friendly. These contented and healthy captives are general favorites.

Some of the kangaroos have lived at Melbourne Zoological Gardens for fifteen years, and still are in good condition. They are familiar friends of mine. But I venture into their enclosures with caution. When the old males become "playful," they are apt to be rather dangerous, unless one is watchful. A foolish visitor, who worried a kangaroo he had lured to the wire fence of its paddock, received a cuff from a paw which sent him spinning. He deserved the punishment.

"Boxing" is a natural habit, even a pastime of the kangaroo. The males often have stand-up fights, lasting for half an hour, or even longer. They cuff one another vigorously. Fights are fierce in the pairing season; at other times kangaroos are generally peaceful.

Training boxing kangaroos is not so difficult, since, in their natural way of "fighting," they nearly reproduce many movements of the human boxer. At Melbourne Zoo, once, a professional boxer did some sparring with a grey kangaroo, which won on points!

An irate male kangaroo literally drove a man from the paddock. Two of the animals, on another occasion, got a man down and thumped him with their hind-legs. He was fortunate to escape with only a broken collar-bone and several fractured ribs.

Mr. Wilkie has frequently measured the hops of kangaroos going at high speed, and finds the average distance covered to be about sixteen feet. He has seen a "flying doe" clear a nine-foot fence, and a male scramble over one the same height.

The biggest kangaroo (one of the "red" species) Mr. Wilkie has had in his care, measured seven feet when standing on "tip toe"—that characteristic attitude, especially when the animals are fighting, or at bay after fleeing from dogs.

Many kangaroo-dogs have been killed by the hunted marsupials, which may face the pack, with back to a big gum tree (Eucalyptus), or standing in the water. If it has the chance, a hard-pressed kangaroo will hop into a stream, a lake, or a lagoon, even a waterhole, and await its pursuers. It is formidable, even against odds, and often the dogs, without aid from human allies, would get the worst of the encounter.

I have seen hunting dogs deeply scarred—kangaroo-claw wounds; and some ripped so terribly that they died. I have known dogs to be saved only by the hunter rushing in to brain the kangaroo with a stock-whip or a stirrup, or to shoot at close range. It's not sport; it's butchery: a term applicable to kangaroo shooting from motor cars, which is practised in some places.

Hunting on horse-back is the old colonial method, still favored, though public opinion is gradually turning against this sport, also. It is exciting and has the spice of danger, since at full gallop in rough country, the hunter may be thrown when his horse fails to clear a log or puts its hoof in a burrow or a hole. An "old man" kangaroo, having wonderful powers of endurance, may get clear away when hunted, outpacing both horses and dogs. Brought to bay, he will put up a brave fight. Two dogs might easily fail to bring him down. Three or more, as a rule, form the pack. Then tactics, quite unfair, may end the fight. One dog holds the kangaroo's attention, attacking fiercely in front; giving its companions the opportunity to leap on the marsupial and kill or disable it. Often victory is paid for, a dog being killed and others wounded.

The kangaroo boxes with its fore-feet, and uses the hind ones when fighting for its life. Should the chance offer, it seizes a dog with its fore-paws, and dashes it violently to the ground; or, hugging the enemy, rips it open with a powerful upward blow: the big conical claw on the central toe of the hind foot is a killing-weapon. When the blow is given, the animal's body weight is supported wholly by the tail.

At bay in the water, a kangaroo, when it seizes a dog, always tries to drown it, and often succeeds. But it will not, despite the camp-fire stories one hears, carry a dog to water for this purpose. Rarely, a kangaroo may rush a man. I've never seen such an attack made, but there are records of kangaroos leaping at hunters.

Snaring is one method of getting kangaroos, in vogue more in the past than at present. A thick snare of wire is attached to a post or a log, which is set in a "run" in the bushland or in a paddock fence. This often involves cruelty, for if the snares are not visited night and morning a kangaroo may remain for many hours, struggling for freedom, and suffering horribly.

Aboriginal modes of hunting the kangaroo are many. It may be run down by one man, who follows recent tracks until he sights his quarry. He advances openly and, when the animal goes hopping away, runs after it. Again and again this may happen, until the hunter wins the long race of endurance. Often the end does not come until the second day, the aboriginal sleeping on the track, which guides

A view of the coastal country of Victoria. The habitat of the large wallabies.
From a photograph by Charles Barrett.

The "Cave of Red Hands," Mootwingee Gorge, New South Wales. These caves were frequented by the aborigines, where they cooked and ate the kangaroos that they had killed. From a photograph by Charles Barrett.

him next morning to the kangaroo, perhaps many miles from the little camp-fire.

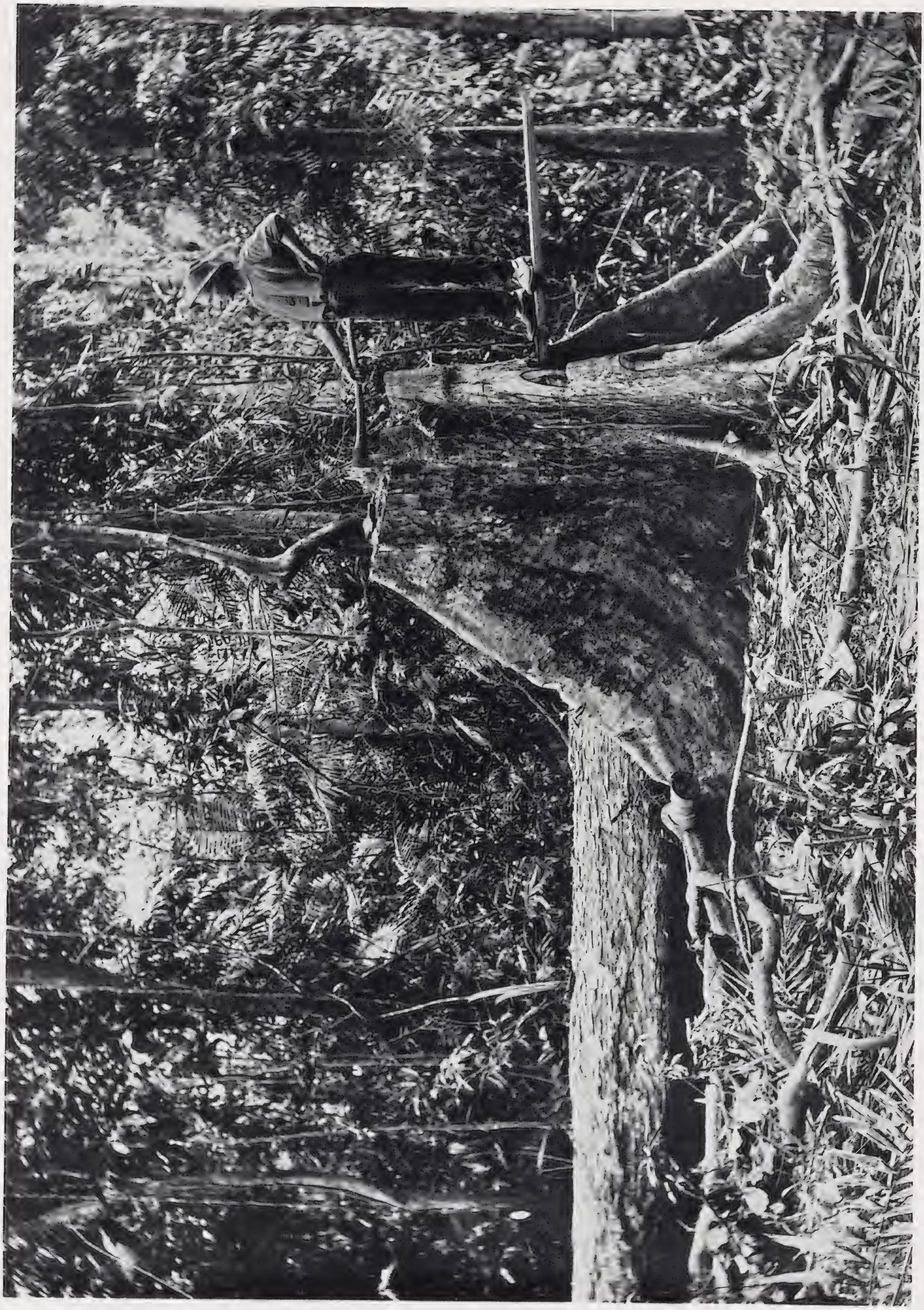
Drives are carried out, the hunters advancing from several directions on a mob of marsupials. Another method is firing the bush, so that the flames will force the kangaroos towards the natives, who are ready with their weapons, to kill. Stalking, with the long-handled spear, is practiced by many of the tribes.

Netting is a usual method, in some districts, of taking kangaroos. Three-sides of a square often are "walled" with nets, and many noisy, naked beaters drive in the kangaroos, which are speared or killed with waddies (clubs). Emus also are taken in this manner.

While kangaroos nowadays are rarely seen near large towns, small parties appear in the vicinity of outback homesteads and farmhouses. They come into the crops. I have seen them often in the Mallee country of north-western Victoria; have come quietly along a lonely road between cultivation paddocks, to surprise the raiders. They stand and gaze for a few moments, heads and shoulders only showing above the wheat or other crop. Then off they go with long hops, clearing the fence at a bound, or scouring through the crowded plant stems. Sometimes they hop across the road in front of a car.

During my motor journey along the Darling River, in New South Wales, last year, I counted nearly 500 kangaroos. Mostly the mobs were small, but occasionally a score or more of kangaroos were sighted, feeding on a green patch among the gum trees. They were frightened of the car, bounding away as soon as they saw it. It was surprising the ease with which they travelled through the forest, avoiding trees and clearing the logs, at high speed. Halting in a patch of timber—old, grey-boled gum trees—they were camouflaged. Their coloration harmonizes with such an environment, though the kangaroos are noticeable enough at a long distance, out on a grassy plain.

When a mob is frightened from the feeding-ground, the does, which are fleeter than the males, and the young are away first. The old males bring up the rear. They are graceful when travelling at any pace, but I like best to watch them going at full speed. A "flying doe"



Rain-forest or "brush," in North Queensland. Small wallabies frequent this class of country, where timber cutters lead lonely lives. Cassowaries were seen in this spot where the tree has been felled. From a photograph by Charles Barrett.

would make a splendid cinema film, if only we could get more than a few feet of such a subject!

Once, a "boomer," as the huge old males are termed, went bounding down the main street of a gold-mining township. There were dozens of men about, but surprise held them still for a while. Then, some with shovels, others with pickaxes or sticks, they began the hue and cry. It was too late: the boomer was already beyond range of their weapons.

Drought, which takes such heavy toll of our wild animals, drives kangaroos and emus, in some localities, close to settlement, in quest of green feed and water. But these animals are able to go for days without drinking and, in a prolonged rainless period, die of starvation rather than thirst.

In poor condition they become an easy prey of the great wedge-tail eagle (*Uroaetus audax*), or eaglehawk, as it is generally termed, and of the wild dog or dingo; natural enemies of large and small marsupials. Hunting in pairs or in packs, dingoes will out-run a kangaroo, which, once down, is quickly killed and eaten. The introduced fox, also, preys upon these marsupials; but full-sized kangaroos are seldom victims of either foxes or the dingo.

Eaglehawks most often take young kangaroos, and will hunt, craftily, in pairs. But the rabbit (introduced into Australia from England, years ago, and now a great pest), has become their usual prey where it abounds.

On some of our country's postage stamps, a kangaroo is depicted, on an outline map of Australia. He spreads over the continent, in this popular design; and in nature, also, the kangaroo—collectively—occupies all Australia. We are considering them as a sub-family (*Macropodinae*), which contains all the kangaroos and the wallabies, varying in size from animals little bigger than a bandicoot to the great red kangaroo, largest of living marsupials.

All classes of country are occupied by these marsupials. Different species have become adapted, through the ages, to different environments. So that kangaroos and wallabies are the most typical Australian animals; and the continent deserves its nickname of Kangaroo Land. As John Bull represents the English, so does a big kangaroo stand for Australia and, with the emu, figures in the coat of arms of the Commonwealth.

In that admirable work, "The Wild Animals of Australasia," A. S. LeSouef and Harry Burrell, give the best general account of the genus *Macropus* I have read; of the genus that includes the typical kangaroos and wallabies, which are divided, roughly, into three groups: the larger kangaroos, the large wallabies, and the smaller wallabies. Concerning environment, the authors say:

"Thus we have the grey kangaroo living in the open forest to which its brown-grey coat is well suited; the black-faced kangaroo inhabits the denser thickets, in the shade of which its brown fur is almost indistinguishable; on the plains of the interior, more often than not on red soil, the red kangaroo has its home; while the powerful wallaroo is perfectly at home on the rough hillsides. The wallabies keep close to cover, hiding during the day among the scrub and undergrowth and coming out in the evening to feed at the edge of the thickets."

It has been my fortune to travel widely in the wilder parts of Australia, and to visit some of the remotest unsettled areas. Thus, I have become familiar with all the various kinds of country inhabited by kangaroos and wallabies. I have followed the tracks which these animals make, through scrub and in timbered country, and in rocky regions; tracks leading often from one favorite feeding place to another.

During the daytime, kangaroos, as a rule, prefer rest to activity. One finds them lying at ease in the shade of a tree; in a natural forest clearing; or—the wallaroos—in a rock-shelter or a cave, frequently a sheltered place in the sun. Many a sign of their presence have I noticed, when riding through their haunts, without sighting kangaroos. They form shallow holes in the ground, which serve both as dust-baths and "beds."

Feeding-time, usually, begins towards the evening; and at sunrise you may come upon mobs "going home." Often, when boiling the "billy" (the tin can in which we brew tea), at my camp in the evening, I have thought, "The kangaroos are going to their feeding-grounds now." The old males are last when a mob is pursued, as already mentioned; but, moving out to dinner, they go first, according

Desert and "sown" in the Mallee. The figure of the man is standing in the midst of young wheat near the edge of the uncleared country. In the evening these fields of wheat are raided by the kangaroos coming from the thick scrub which adjoins the "sown." Mallee is a dwarf species of eucalyptus which grows in dense masses, forming an admirable cover for game. It is called mallee-scrub. From a photograph by Charles Barrett.

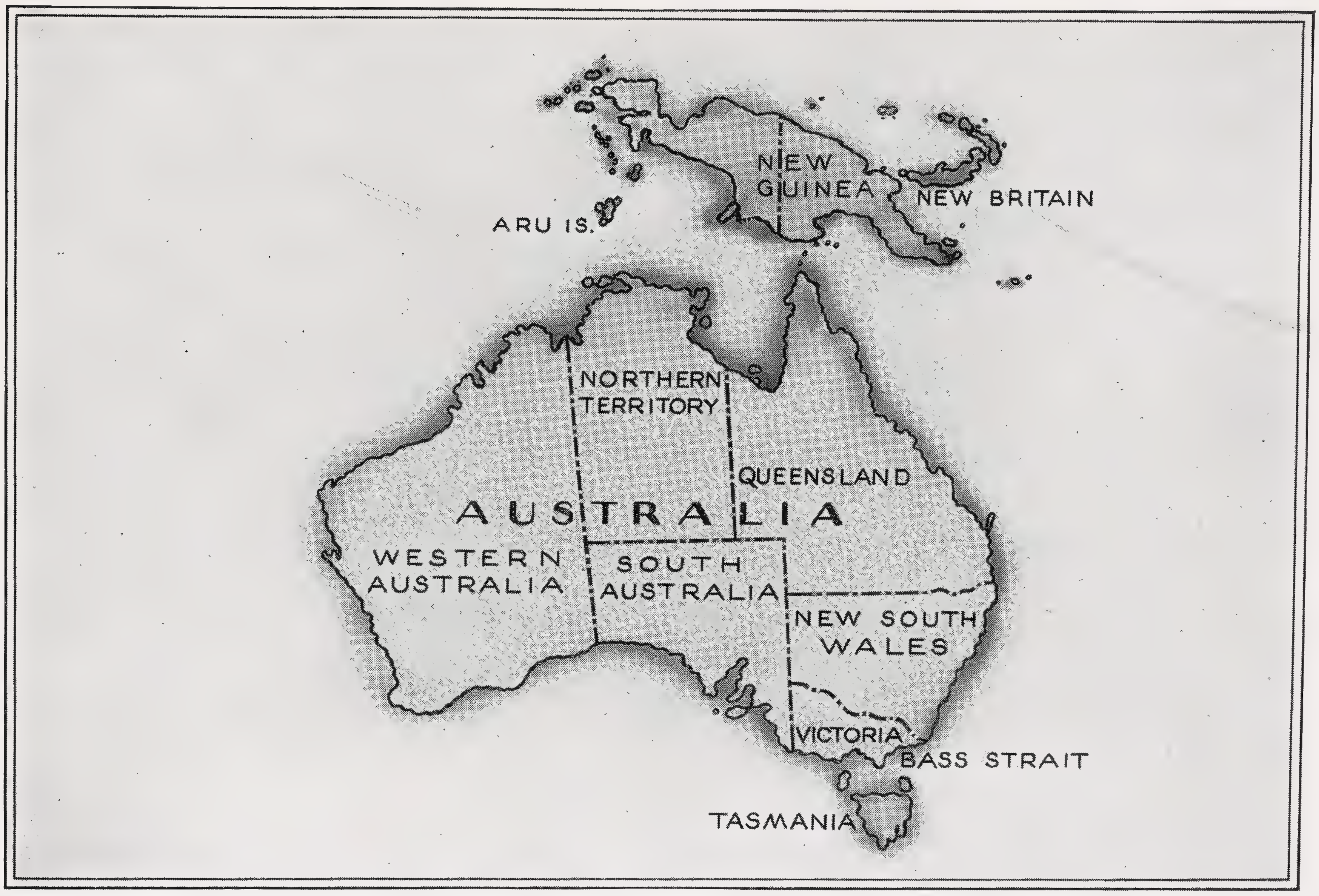
to careful observers of kangaroo ways in the wild.

Of their intimate home life we know little, beyond what has been learned from the study of captive kangaroos. No one yet has written a full-length biography of any species of kangaroo, though pages, even chapters, by various hands are plentiful enough. It is a book that we need; on the lines of Burrell's platypus monograph.

Naturalists are trying to save the marsupials, but Governments are slow to recognize the need for conservation. Thus, in Victoria, this year, despite the advice of scientists and field naturalists, and much public disapproval, an open season for opossums (phalangers) was declared. More than 500,000 pelts were taken. The result is, opossums have disappeared from some districts, and become rare in others. The toll has been too heavy. Efforts now are being made to save the marsupials; to gain for them closer protection. At a recent "Marsupial Night," organized by the Field Naturalist' Club of Victoria, opinions expressed were strongly in favor of the movement.

Professor F. Wood-Jones, F.R.S., the distinguished anatomist and leading authority on the marsupials, in a letter read before the meeting, said: "That an effort is being made to awaken public conscience in the matter of preservation of the marsupials is, to my mind, an extremely good and necessary thing. . . . . . I do not think most people realize how very ignorant we still are concerning the more intimate life details of these animals for which we must consider ourselves as trustees. There are enormous gaps in our knowledge of life histories, physiology, anatomy and development of the marsupials . . . . . . The marsupials must be preserved for humanitarian and aesthetic reasons—but they must also be preserved because they are capable of yielding up so many biological secrets that may yet be solved to the possible benefit of humanity."

There is no longer a mystery about the birth of kangaroos, though many stubborn, if not



Distribution of Kangaroos and Wallabies*

Compiled by James A. Kershaw, Director, The National Museum, Melbourne

Kangaroos

Macropus giganteus—Australia, except centre and extreme north.
M. giganteus fuliginosus—Tasmania.
M. isabellinus—North West Australia.
M. rufus—New South Wales; Victoria; South Australia; Central Australia; West Australia.
M. robustus—Queensland; New South Wales; South Australia; Northern Territory; North West Australia.
M. bernardus—Northern Territory.

Wallabies

Macropus ualabatus—New South Wales; Victoria.
M. ruficollis—New South Wales; Victoria; Southeastern South Australia; Islands in Bass Strait.
M. ruficollis bennetti—Tasmania; Islands, Bass Strait.
M. greyi—South Australia.
M. dorsalis—Queensland; New South Wales (interior).
M. billardieri—Victoria; Tasmania; South Australia (Southeast); Islands in Bass Strait.
M. brachyurus—West Australia.
M. parryi—Queensland; Northern New South Wales (coastal ranges).
M. irma—West Australia (southern districts).
M. agilis—Southern New Guinea.
M. wilcoxi—South Queensland; New South Wales.
M. thetidis—South Queensland; New South Wales.
M. coxeni—North Queensland.
M. stigmaticus—Northeastern Queensland.
M. brunii—Aru Island.
M. browni—Duke of York Island; East and Southeastern New Guinea; New Britain.
M. eugenii—West Australia; Islands off coasts of West and South Australia.
M. parma—Eastern New South Wales.
Lagostrophus fasciatus—West Australia.
Onychogale unguifera—North and North West Australia.
O. frenata—Queensland to Victoria.
O. lunata—Western Australia; South Australia; Central Australia.

Rock Wallabies

Petrogale xanthopus—South Australia (northern) and into Central Australia to New South Wales border.
P. penicillata—East Coast—Queensland to Victoria.
P. lateralis—West Australia; Central Australia.
P. brachyotis—North West Australia.
P. concinna—North West Australia.

Hare Wallabies

Lagorchestes hirsutus—West Australia.
L. leporoides—New South Wales; Victoria; South Australia.
L. conspicillatus—North and Northwest coasts of Australia.

Tree Kangaroos

Dendrolagus lumholtzi—Northern Queensland (Herbert River district).
D. bennetti—Northern Queensland (Bloomfield River district).
D. ursinus—Northwest New Guinea.
D. dorianus—Southeastern New Guinea.
D. inustus—Northwestern and eastern New Guinea.
Dorcopsis muelleri—Northwestern New Guinea and adjoining islands.
D. luctuosa—East and Southeast New Guinea.
D. macleayi—South coast, New Guinea.

Rat Kangaroos

Aepyprymnus rufescens—New South Wales; Victoria.
Bettongia cuniculus—Tasmania; Victoria.
B. gaimardi—New South Wales.
B. penicillata—New South Wales; Victoria; South Australia; West Australia (southern districts).
B. lesueuri—South Australia; West Australia (southern districts).
Caloprymnus campestris—South Australia (probably extinct).
Potorous tridactylus—New South Wales; Victoria; South Australia; Tasmania.
P. gilberti—West Australia (southern districts).
P. platyops—West Australia (southern districts).

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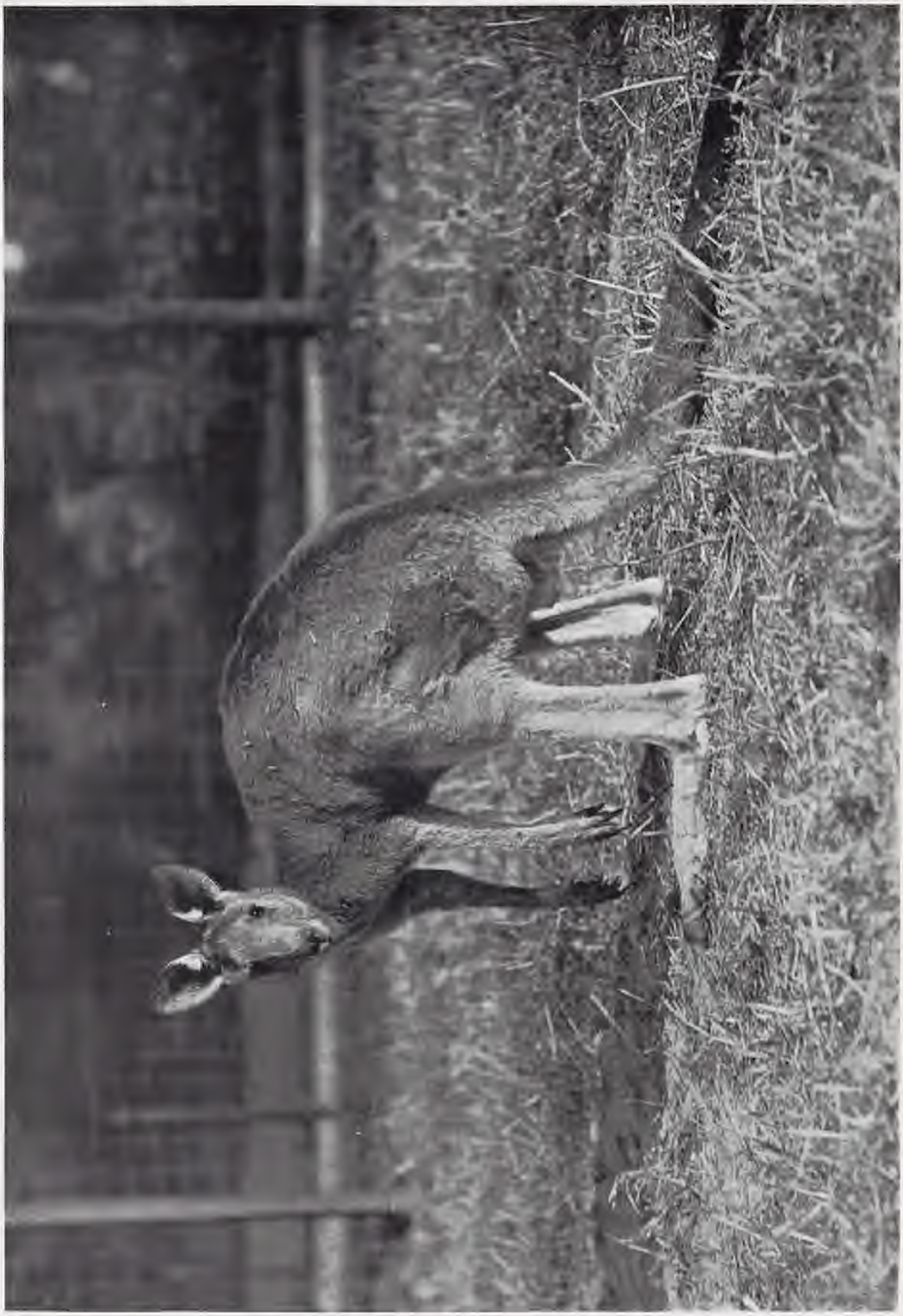
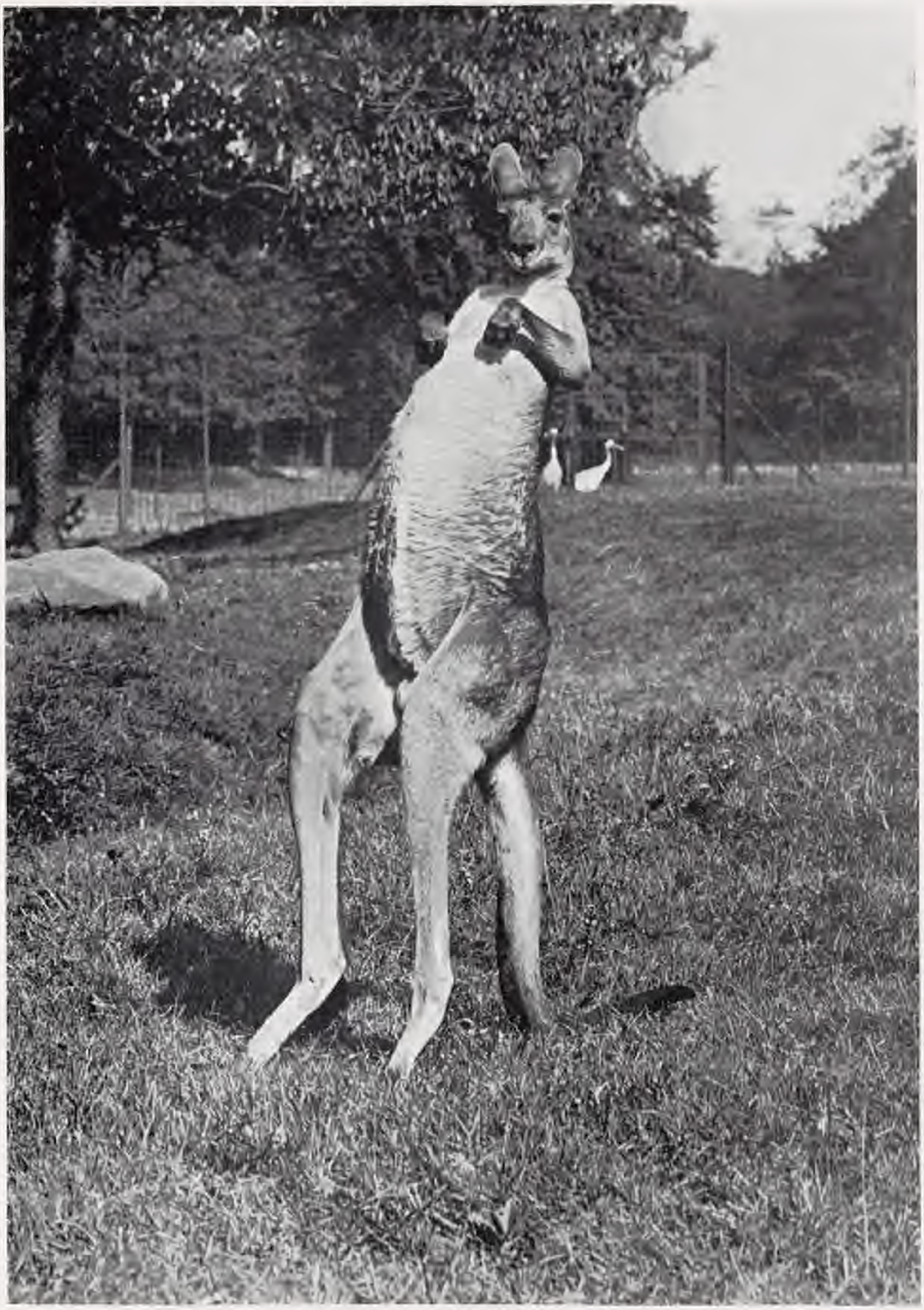
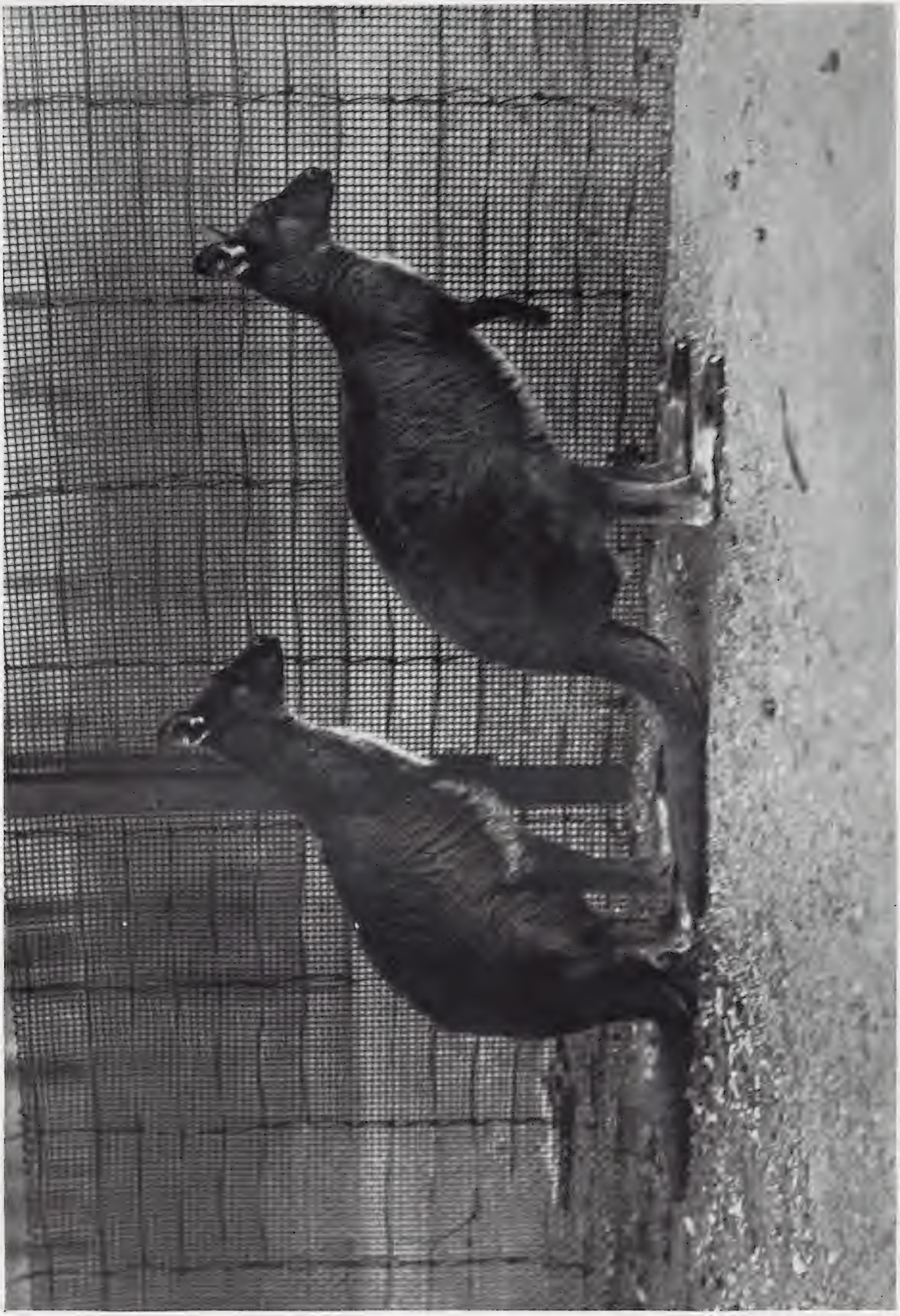
* Doubtful species not included.



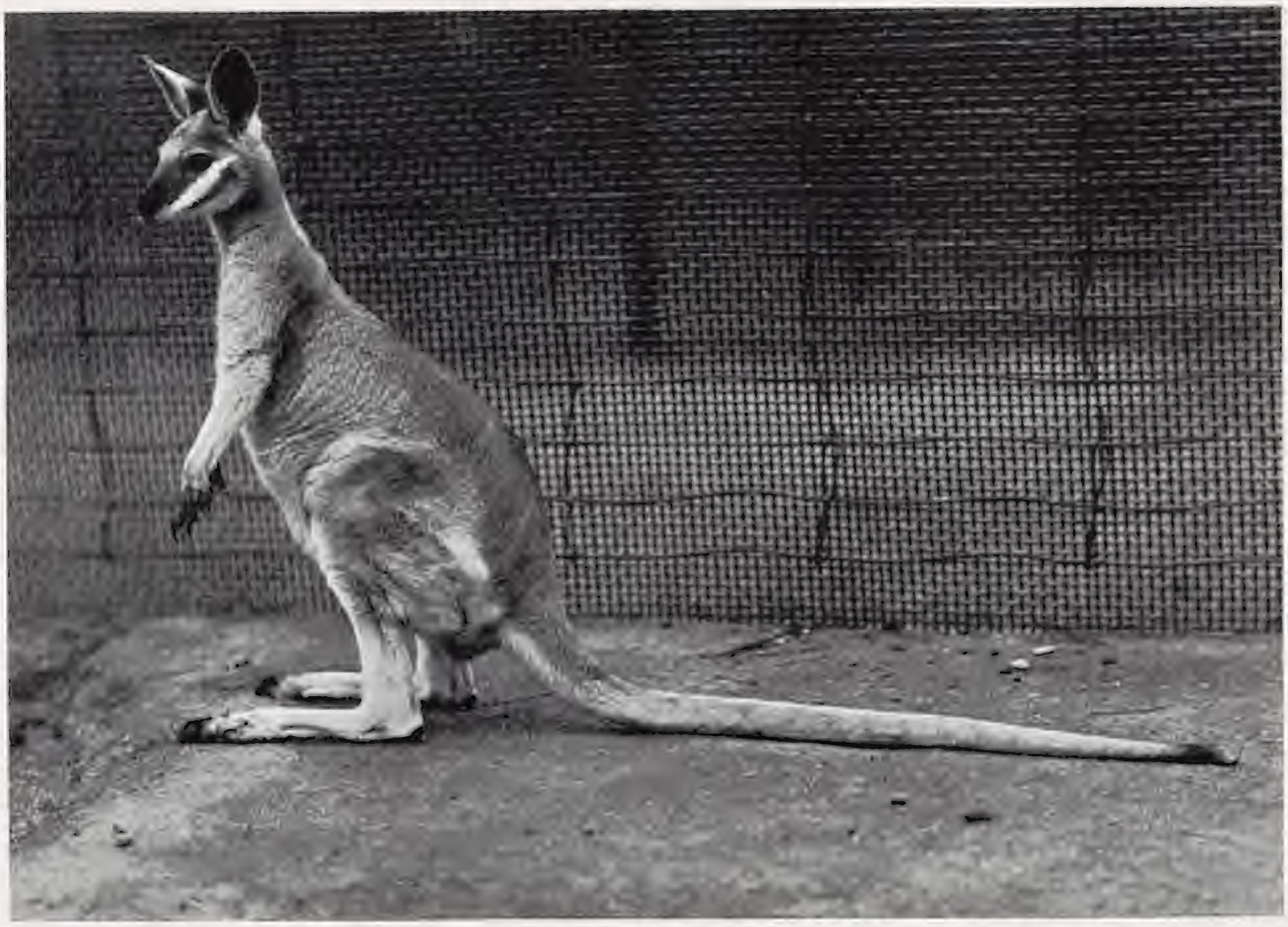
Gray Kangaroo. A species common throughout the greater part of Australia except the central and extreme northern areas. Photographed in the New York Zoological Park.

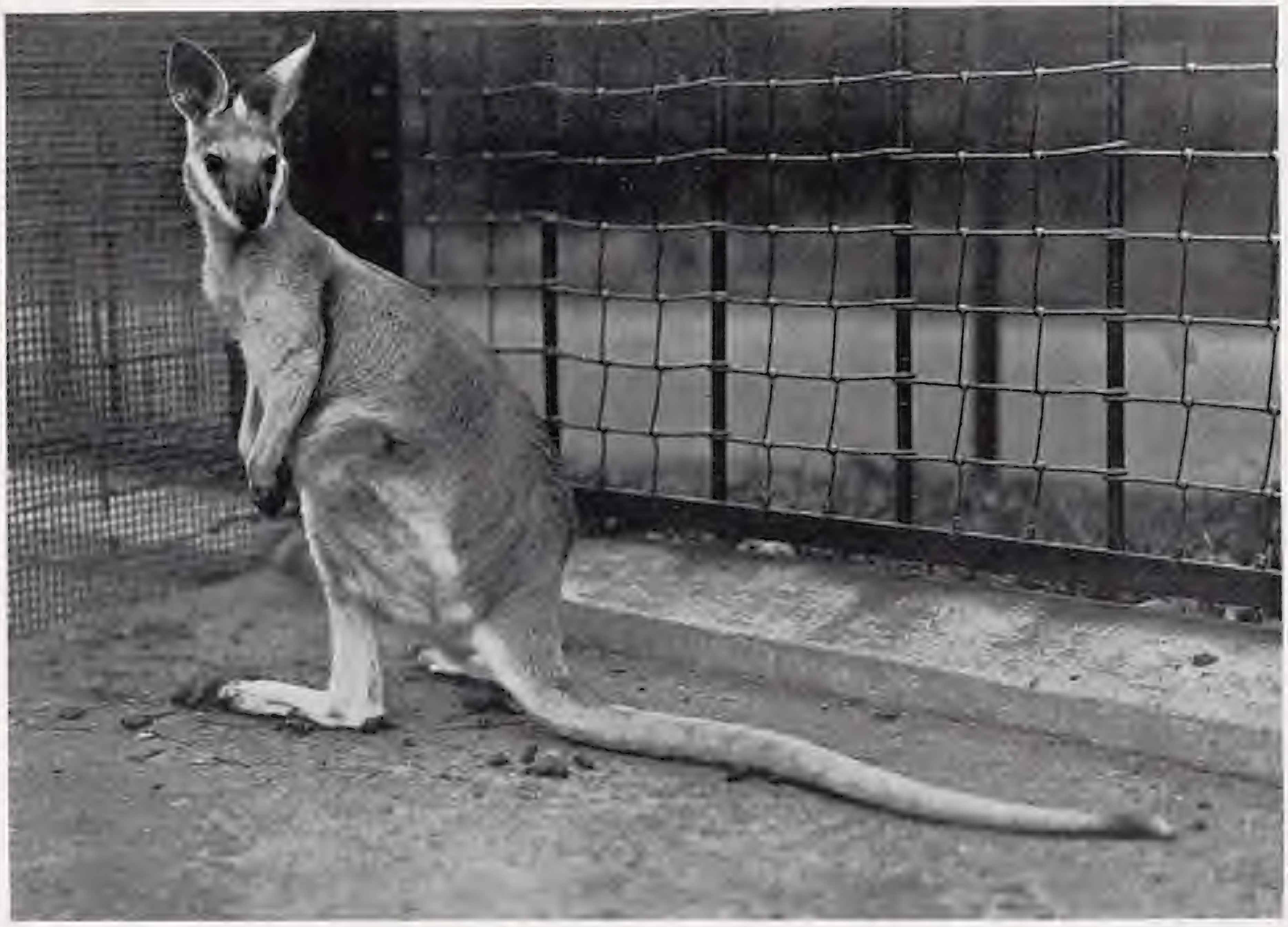


Giant Red Kangaroo. This species is the largest of the kangaroos. When standing erect it is over six feet in height. Photographed in the New York Zoological Park.



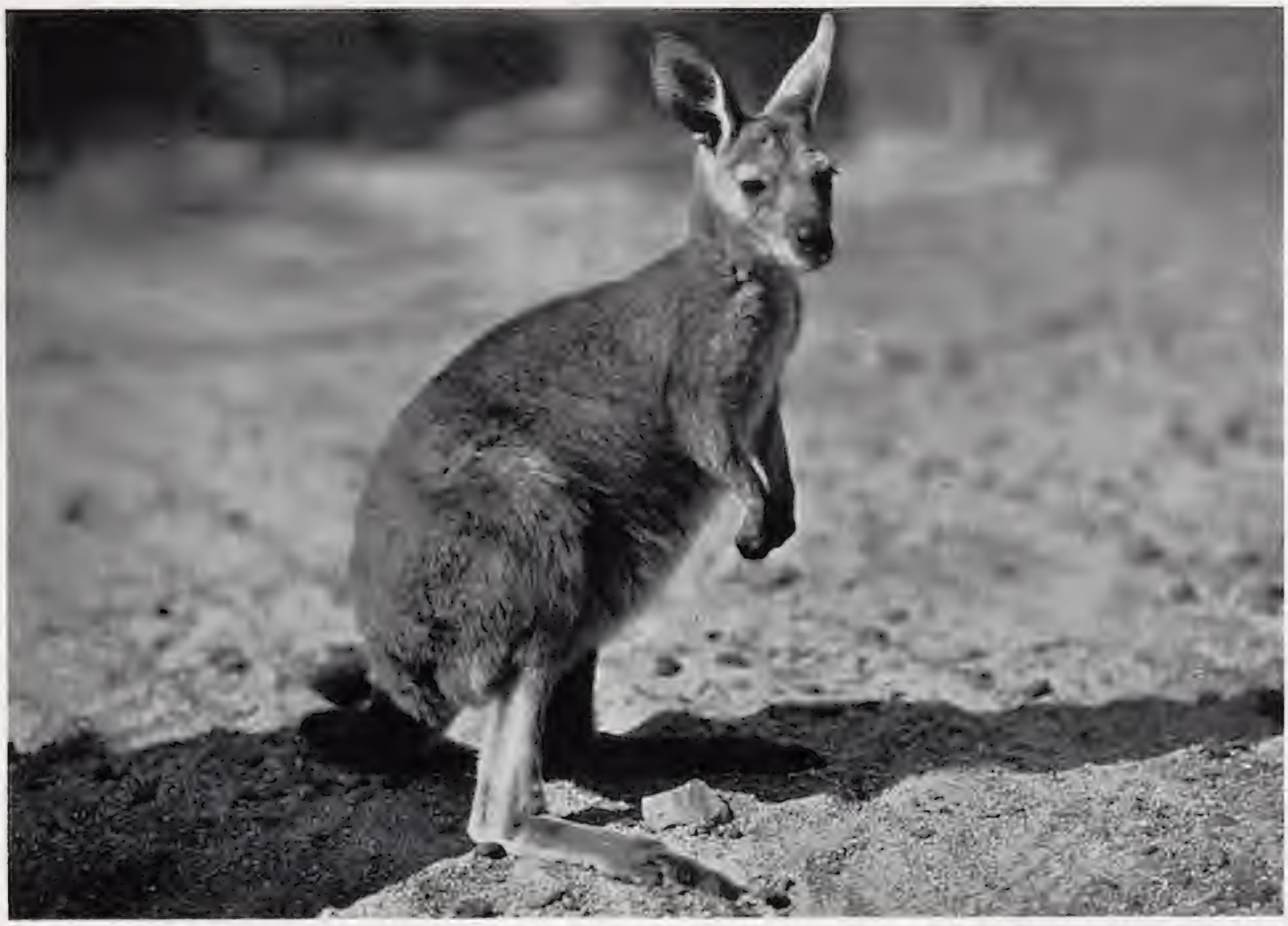
Island Kangaroos. Found in Tasmania and Kangaroo Island. A species that has become very rare. Photographed in the New York Zoological Park.

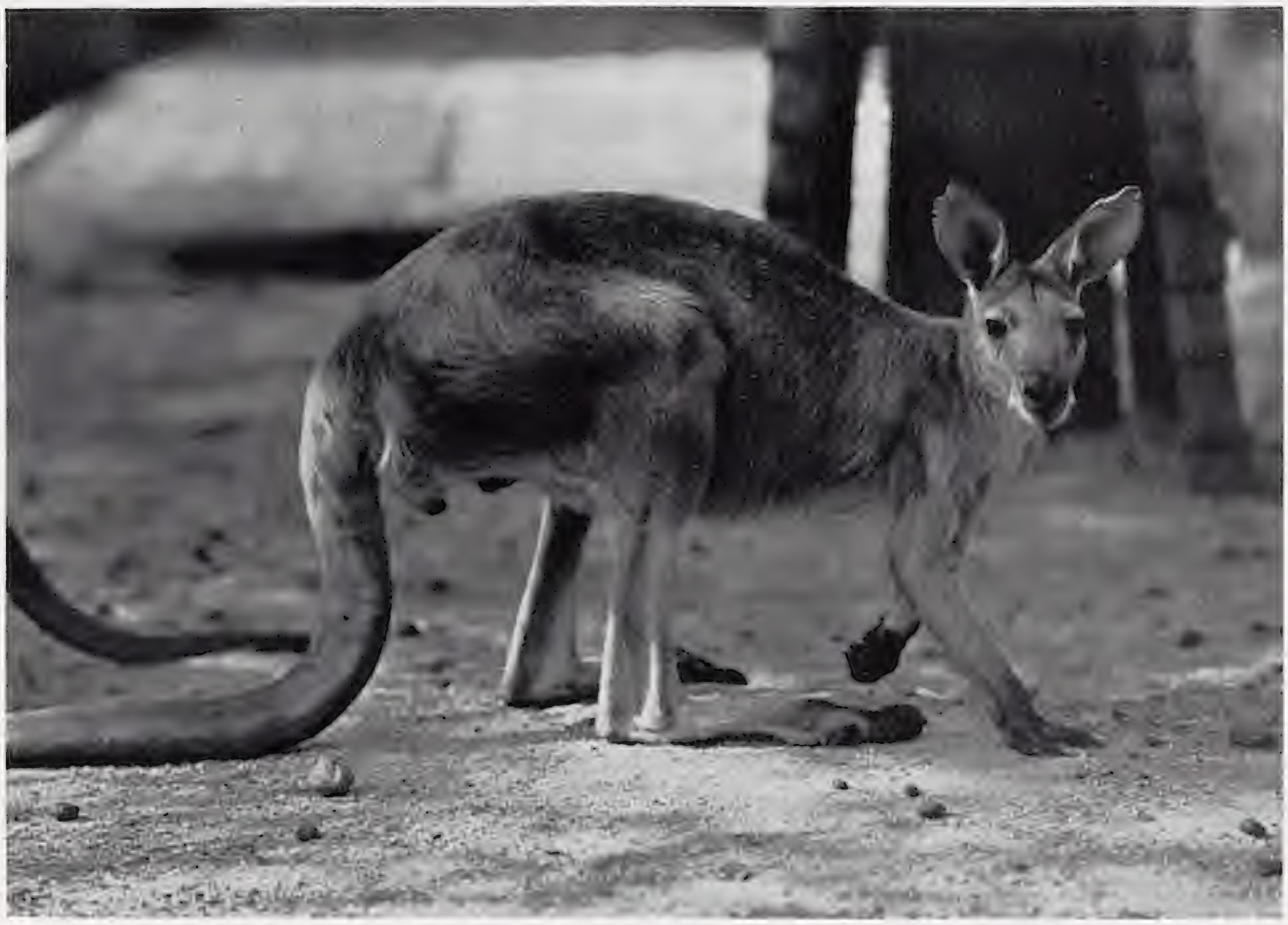




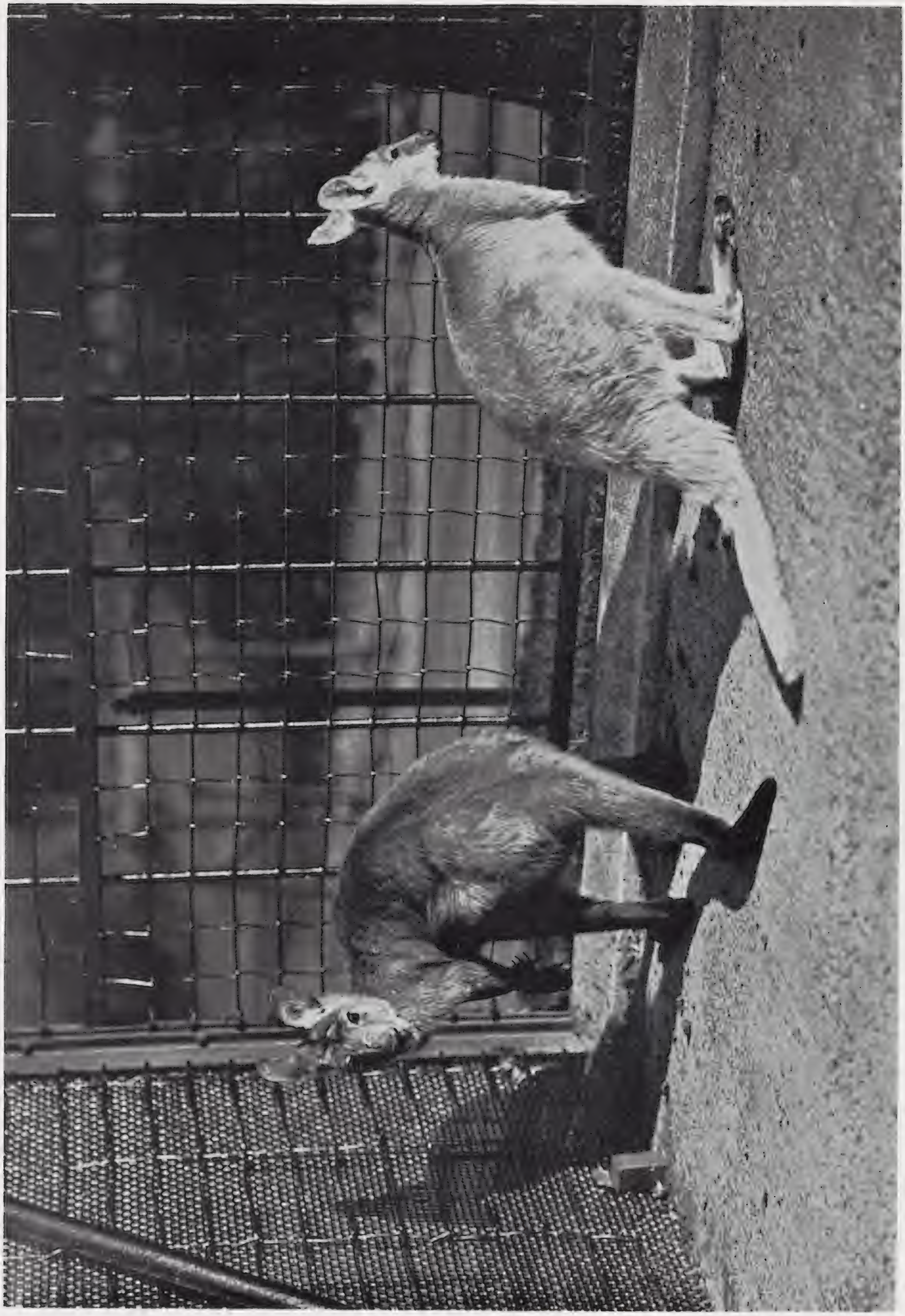
Parry's Kangaroo is a small and slender species frequenting the hilly coastal districts of Queensland and northern New South Wales. Photographed in the New York Zoological Park.

The Black-faced Kangaroo lives in the dry and sandy districts of southern Australia where the mallee eucalyptus grows. Since its habitat is in a good wheat producing locality, it is becoming scarcer as the land is cleared. Photographed in the New York Zoological Park.

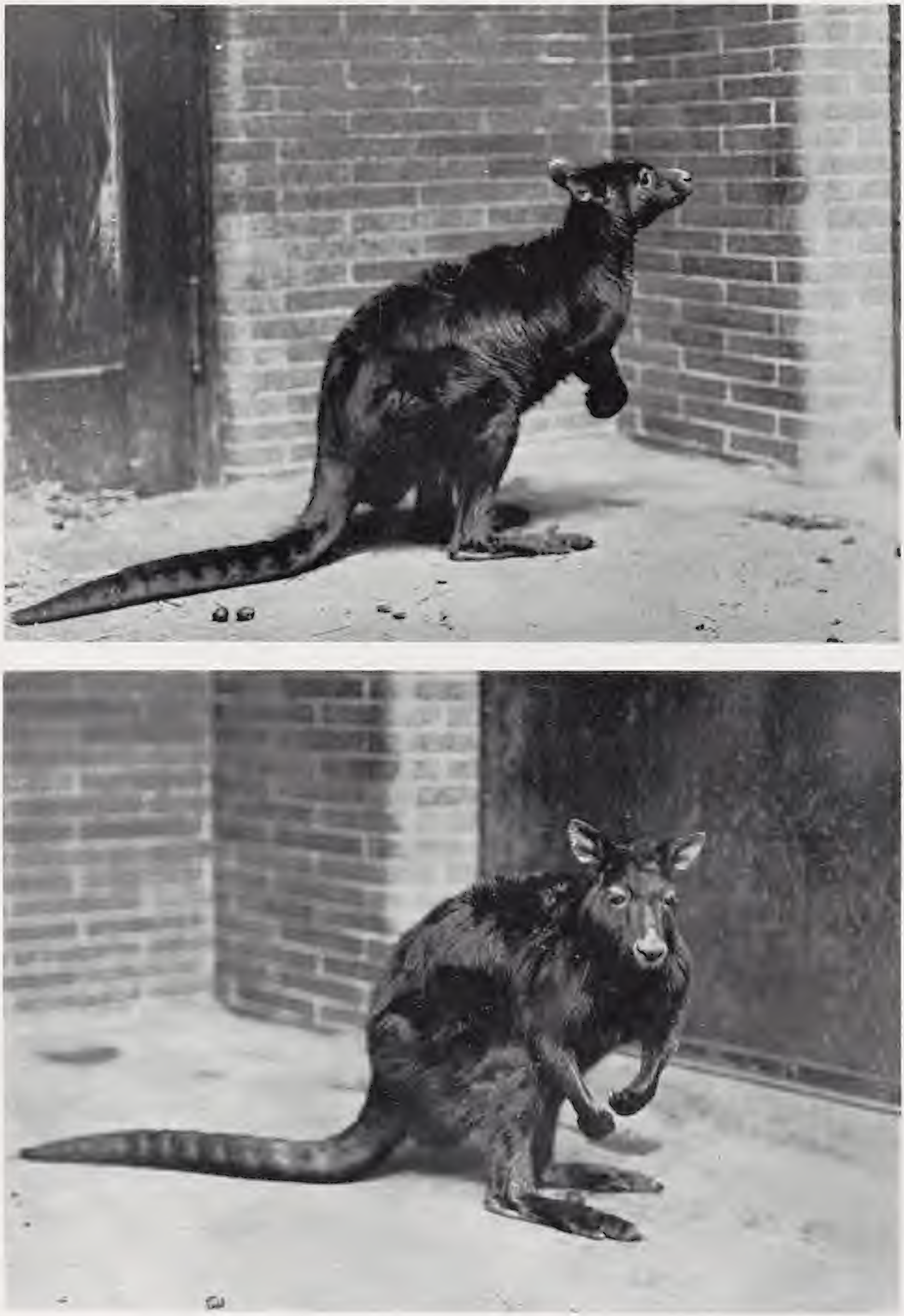




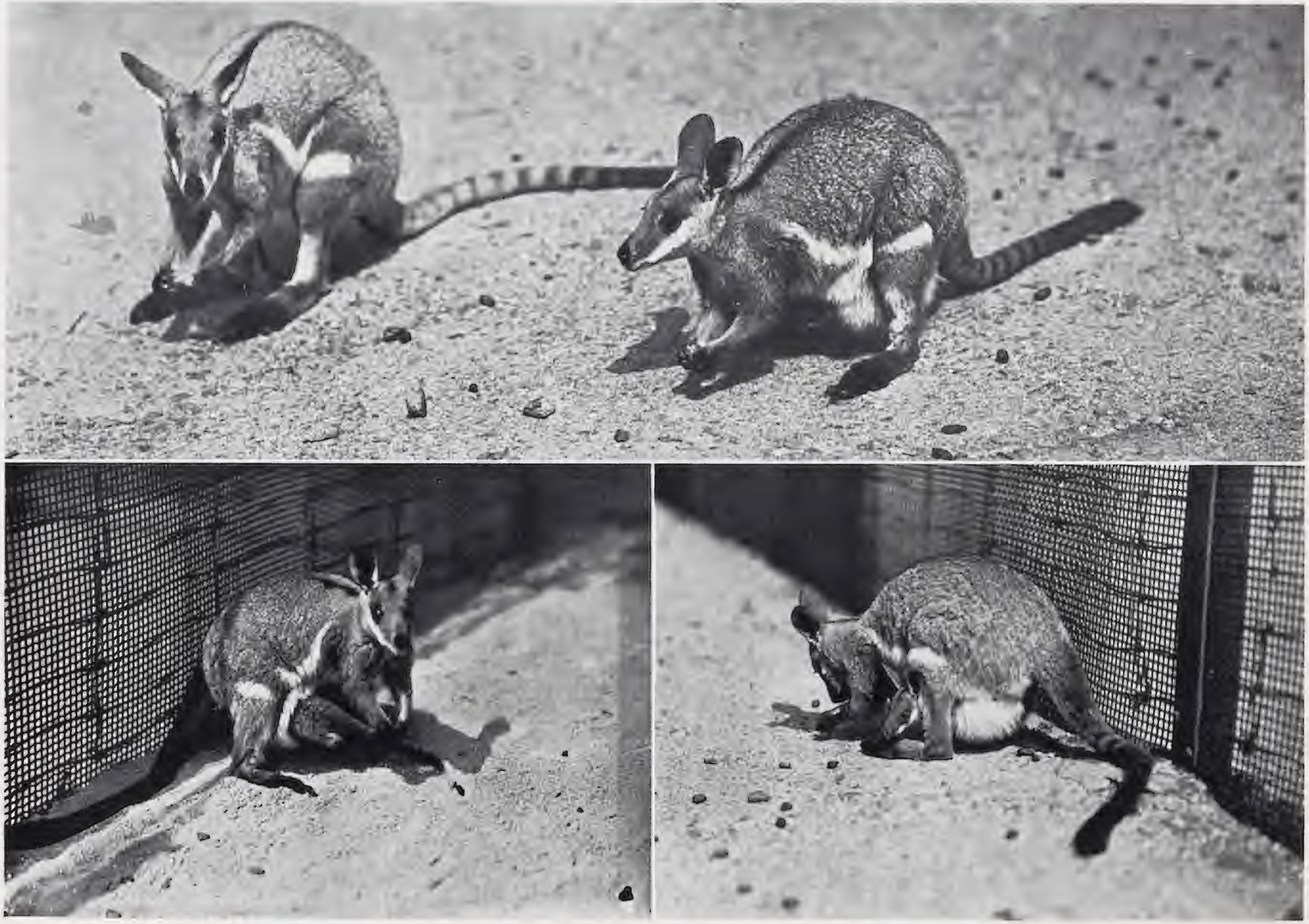
Woodward's Kangaroo is confined to northwest Australia. The color of the male is a bright red and that of the female, fawn. Photographed in the New York Zoological Park.



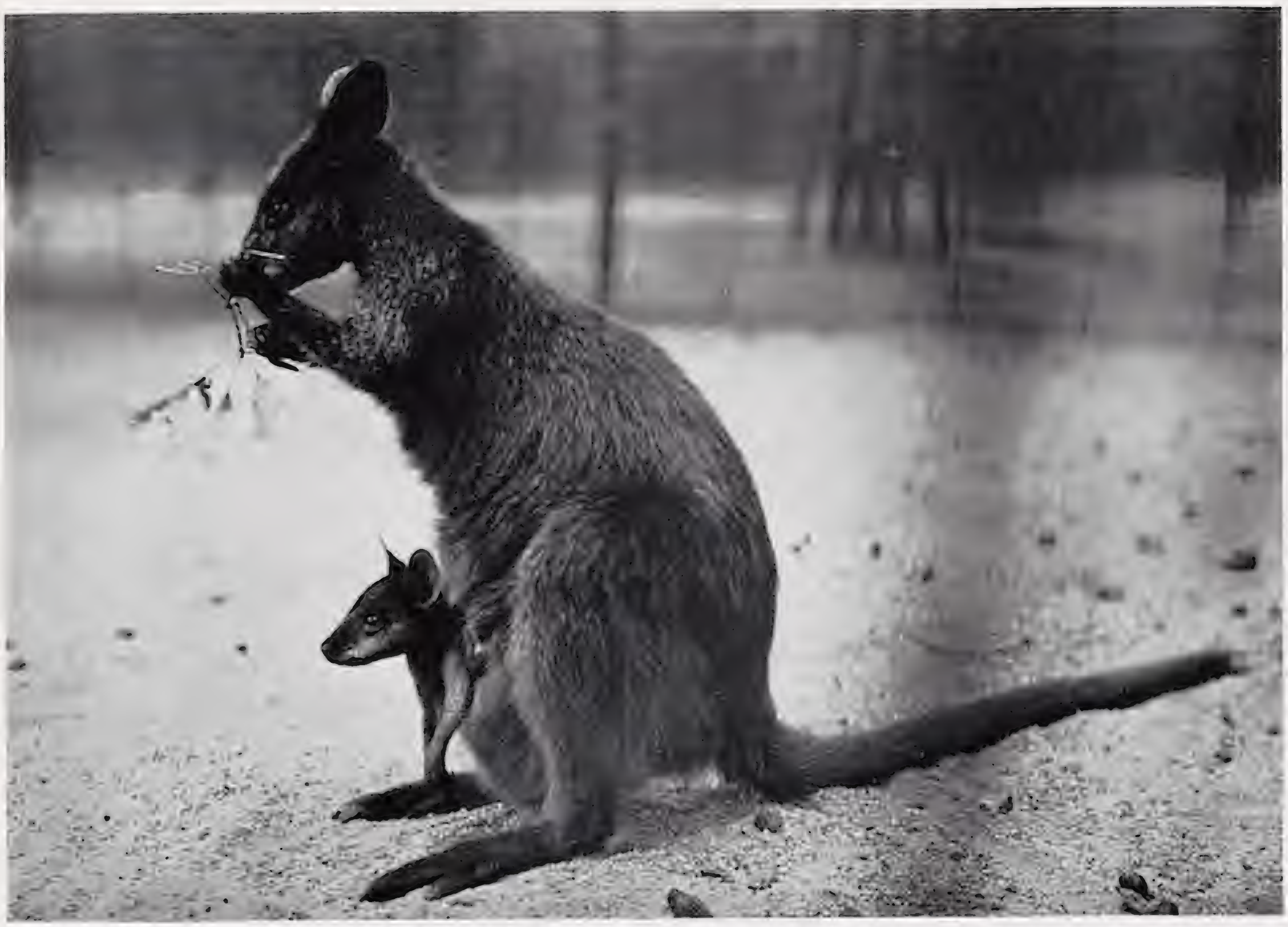
Wallaroo or Euro Kangaroo. The color of the male is a dark gray, tinged with red; the female a blue-gray shade and much lighter in tone. They are well set up and thoroughly adapted to the rough, rocky country in which they live. Photographed in the New York Zoological Park.

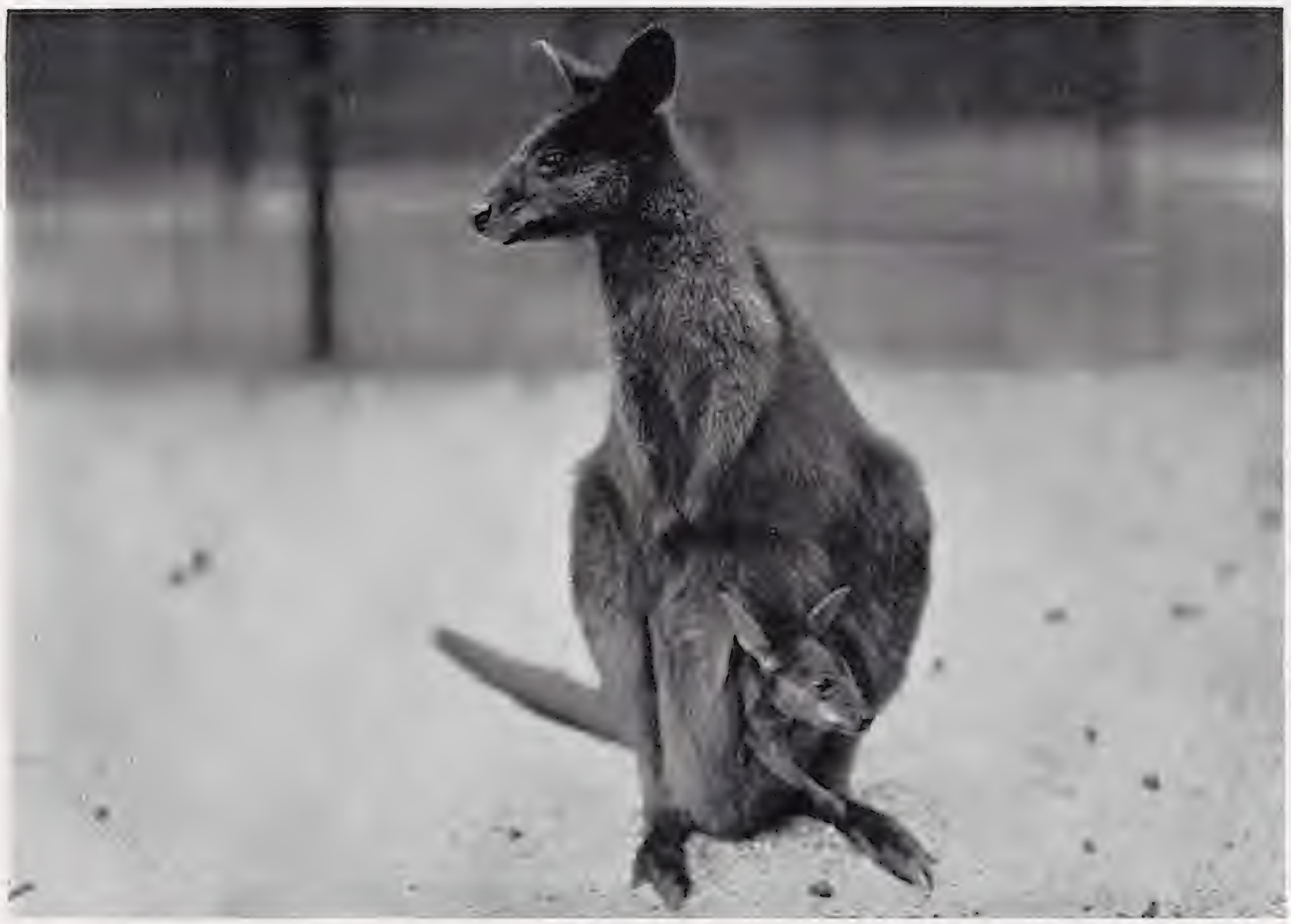


Bernard's Kangaroo, *Macropus bernardus,* is found in the Northern Territory of Australia. It is distinguished by its thick and very dark pelage. Photographed in the New York Zoological Park.

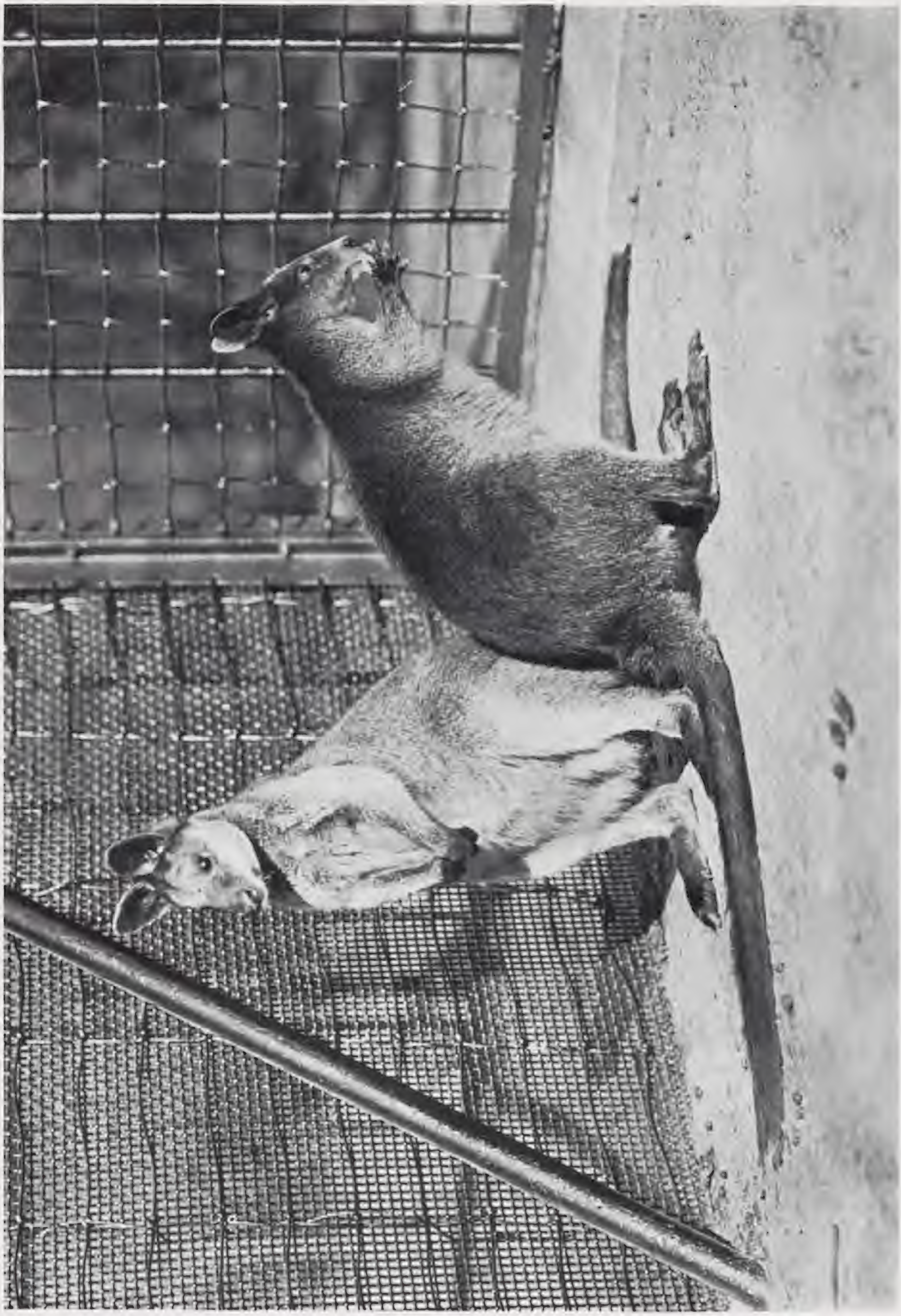


Ring-tailed Wallabies. One of the smaller wallabies distinguished by the prominent white stripe extending along the side to its hip and the ringed tail with black brush-like tip. In the lower picture, a young animal may be seen in the "pouch." Photographed in the New York Zoological Park.

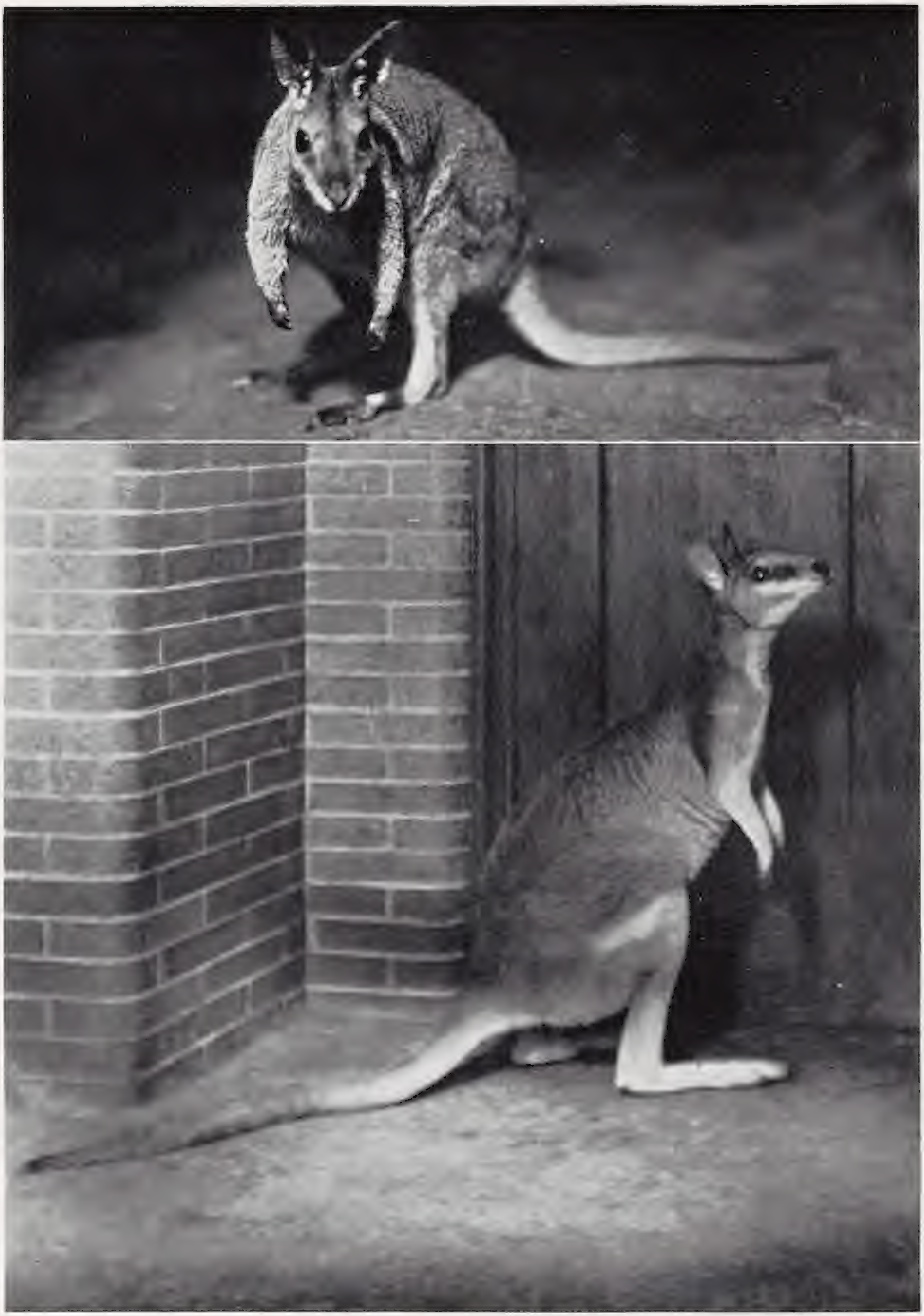




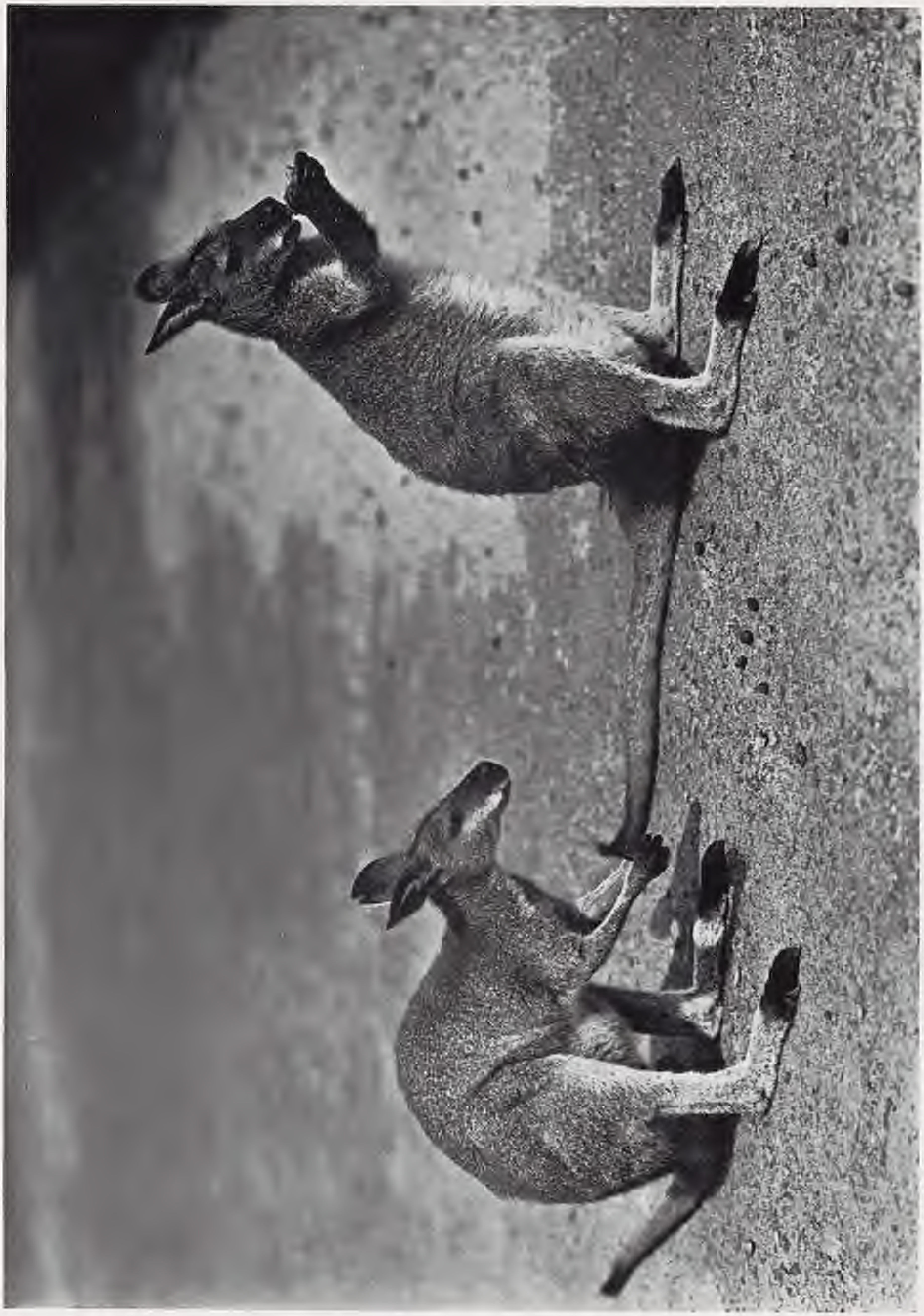
Black Swamp-Wallaby. One of the larger of the wallabies, with very dark, long and coarse fur. The young animal in the mother's pouch has nearly outgrown its haven of safety. Photographed in the **New York Zoological Park.**



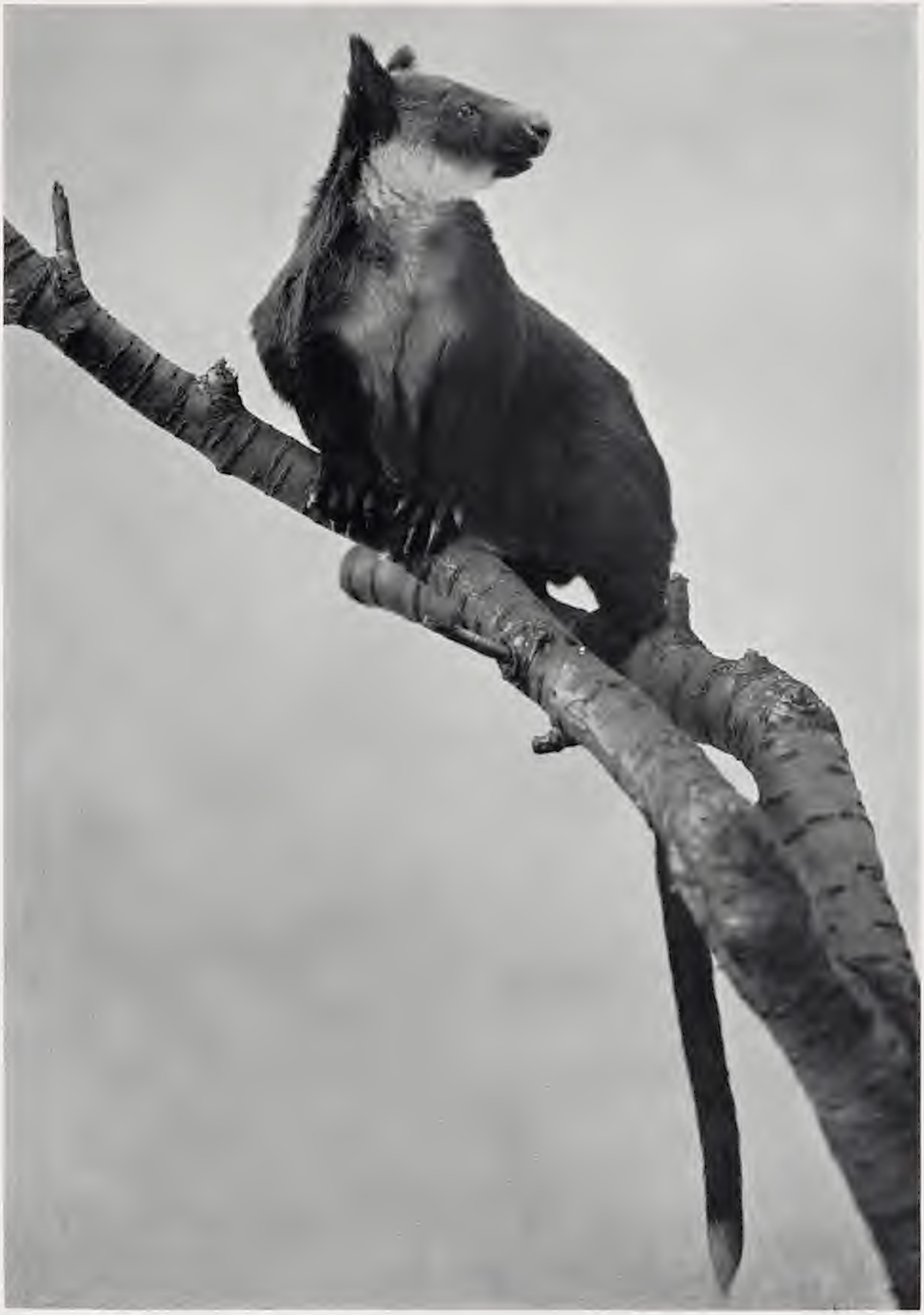
Black-tailed Wallabies. This animal is rather heavy in structure and not so active as many of the smaller wallabies. It lives in scrub or bush country. The male is dark brown in striking contrast to the very pale gray of the female. Photographed in the New York Zoological Park.



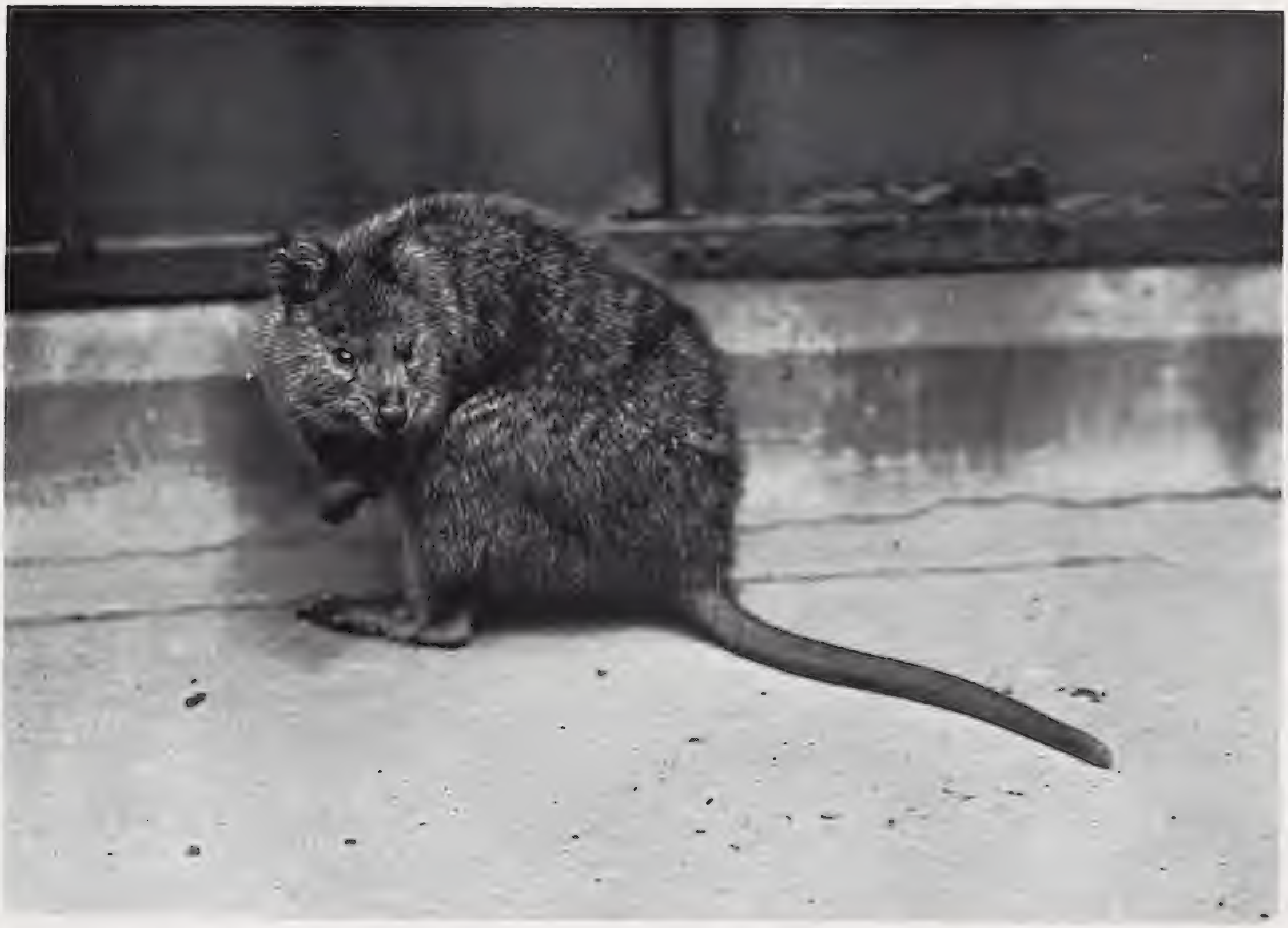
The Nail-tailed Wallaby (*top*) derives its common name from the spur at the end of its tail. Among mammals, the lion is the only one similarly equipped. The Agile Wallaby (*lower*) is a slender species distinguished by the long, slim tail. Photographed in the New York Zoological Park.

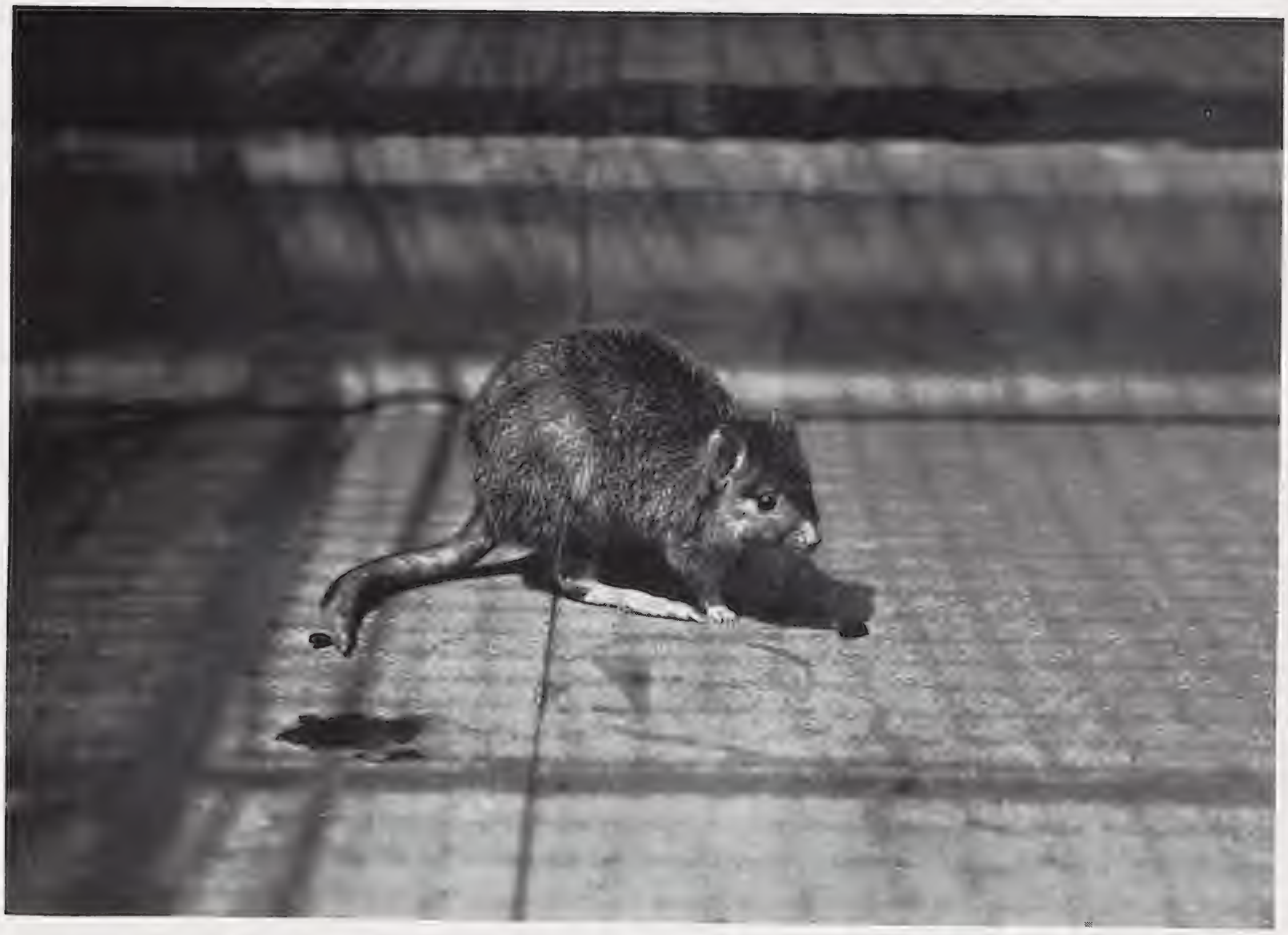


Rufous-necked Wallaby, or Red-necked Wallaby is found in the open forest country of the Eastern parts of Australia from Southern Queensland to Victoria. Photographed in the New York Zoological Park.



Bennett's Tree-kangaroo. This interesting kangaroo, termed wallaby by the late W. H. D. Le Soeuf, is an agile climber, feeding almost entirely in tree tops. The tail forms an effective balance. It is not prehensile nor is it used in the manner of its terrestrial relations. Photographed in the New York Zoological Park.





The Short-tailed Wallaby (*top*) is the smallest of this group. Its body is about twenty inches when erect and the tail a trifle over one-half that length. The West Australia Rat-kangaroo, locally kangaroo rat, is a small animal about eighteen inches long, with tail one-half that length. Photographed in the New York Zoological Park.

stupid, bush "naturalists" and city folks quite untaught in biology, cling to the old belief. "The young are born in the pouch," these wiseacres declare; some even assert that the embryo grows from its mother's nipple! You cannot convince them that these are "vulgar errors." I receive, occasionally, almost abusive letters on the subject, from men who sign themselves "Old Bushman," "Station Hand," etc. It is rather amusing.

Newly-born kangaroos are unlovely objects, but of the deepest interest. They are naked and barely an inch in length, tiny, but not quite helpless things. Born, of course, in the normal manner among mammals, the infant kangaroo climbs up to the pouch through its mother's fur. So slowly does it move, however, that its first "journey" occupied perhaps half an hour. The mother often does not help her offspring; indeed, appears to ignore its existence. Sometimes she may aid it with her lips. It may become lost for a while, in its wandering through a "forest" of fur, from the ground to its future nursery. Once safely inside the pouch, it fastens on the nipple, which pointed before and firm enough for the infant mouth easily to seize, becomes enlarged while it also softens—a kind of bulb. The young one appears to have grown from it, so close is the nipple's alliance with the mouth! It can be removed only by main force, causing rupture, as a rule.

Several months are required for the young kangaroo to develop its fur covering and grow into a miniature image of its parents. It is charming to see one, when between three and four months old, looking out on the world from the pouch.

The young animal, for some time after it has learned to venture "abroad," and nibble at the grass when hungry, keeps near its mother. Frightened, it hops at once to the parent, and seeks safety in her pouch.

Giants of the Past:—None of the existing kangaroos approaches in size the giant extinct forms, whose fossil remains are found in many parts of Australia. During the Pleistocene period, *Macropus titan* flourished. It was allied to the gray kangaroo (*M. giganteus*), most familiar of all the living species, and the one usually seen in Zoological Gardens, both in Australia and overseas. A full-grown male grey

Typical Mallee country in northwestern Victoria. This type of country is the habitat of kangaroos and scrub wallabies. From a photograph by Charles Barrett.

kangaroo will weigh about 200 lbs.; and from nose to base of the tail, measure over five feet; the tail itself being about four feet four inches in length. *M. titan* was of much larger size, a veritable monster of the past.

Giant wallabies, also, flourished during the Pleistocene period. Some species had skulls twelve inches in length. The remains of several extinct genera have been discovered. Such fossils are plentiful in superficial deposits, as well as in caves, deep and shallow.

At Puralka, in western Victoria, a "find" of fossils was made in a shallow limestone cavern. I went down to examine the site, and collect material. Remains of *M. titan* and other gigantic kangaroos were obtained. But more exciting was an artefact, a small stone implement, discovered by the pastoralist who first delved in the cave. This "Puralka Flint," as it is generally called, was associated with the fossil marsupial bones, and is one of the most ancient relics of the kind hitherto discovered in our country. Thousands of years ago, when the monster kangaroos roamed the western plains or lived in the open forest areas, they had "Stone Age" men to hunt them.

We are on the trail of ancient man in Australia. Did he hasten the end of *M. titan, M. atlas,* and other huge marsupials, as the *Diprotodon,* which had a skull three feet in length and was the size of a rhinoceros?

Reports are occasionally received of "boomers" in wild places remote from settlement. Quite recently I heard of one "about 8 feet in height"! It was sighted at a distance; but the observer was sure that his estimate was near the mark! It is certain that both grey and red kangaroos of exceptional size do exist; for growth, in the males, continues even in old age. The "boomers" are animals that for years have escaped all enemies and lived to become giants among the largest younger members of the herd or mob. The females are smaller than the males. This applies to the larger species of wallabies, as well as the kangaroos. Sex difference in size is so marked, that one familiar with the animals, can easily pick out the males in a mob when some distance away. It is usually guess-work, however, where the lesser wallabies are concerned.

The great red kangaroo (*M. rufus*), now becoming scarcer, in parts of its range, but for-

Red-necked wallaby *M. rufficollis* in the Zoological Gardens, Melbourne, Australia.
From a photograph by Charles Barrett.

Black-tailed wallaby *M. ualabatus* in the Zoological Gardens, Melbourne, Australia.
From a photograph by Charles Barrett.

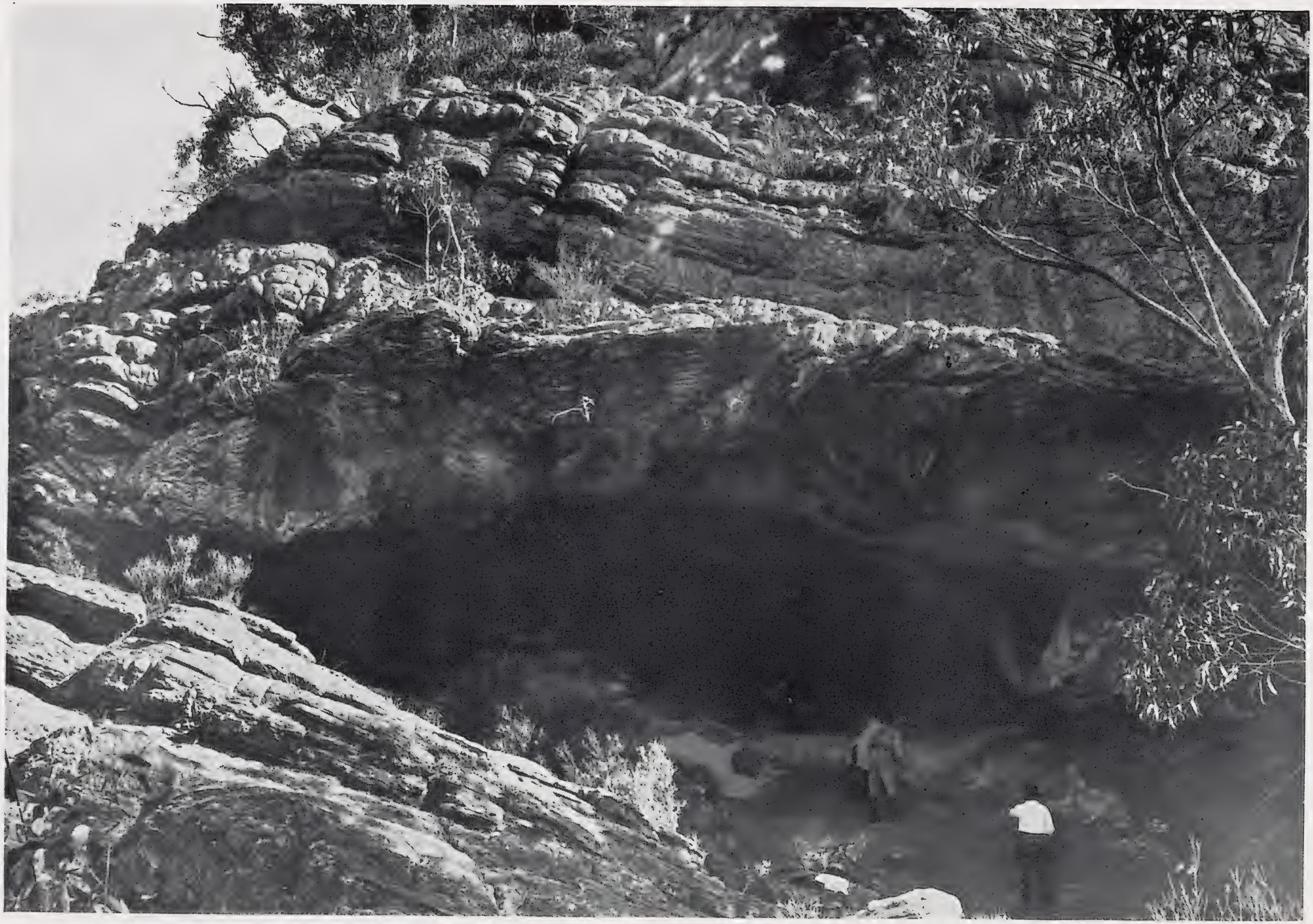
merly very abundant, is the largest and one of the most beautiful species. Its realm is a wide one, on the open inland plains; it does not occur within several hundred miles of the sea, unless exceptionally. I have met with it in mobs of up to a dozen, though often only about half that number associate. Lying at their ease, in the shade of a tree, the reds form a charming group of "Australian natives." The females especially are shapely and slender, and aesthetically colored, the white legs and under-surface contrasting finely with the blue-grey of the back and sides of the body.

In Central Australia, motoring through country traversed afoot and on camels by the Horn Expedition long ago, I saw occasionally small mobs of the red kangaroo. It was a dry season, and much depends upon the rains on the Central plains. In a good season, kangaroos are fairly numerous, where I met with only a few—north of the Macdonnell Range, out towards Central Mount Stuart, practically the centre of Australia.

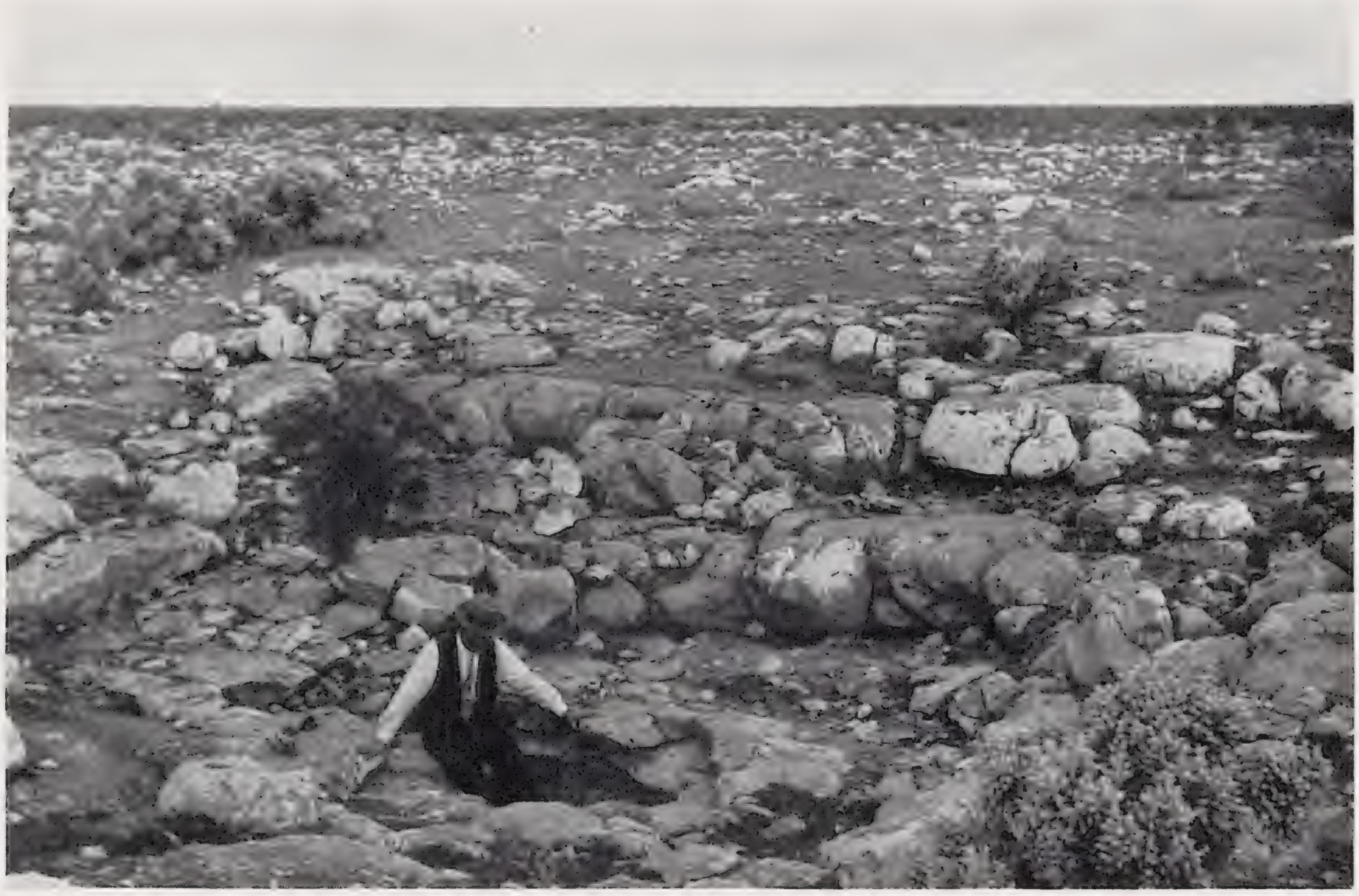
Three sub-species of *M. rufus* have been described; while the grey kangaroo in Tasmania has been regarded as a race of *M. giganteus.* Other sub-species of kangaroos and wallabies have been recognized by systematists; but the field naturalist may not agree with such "splitting."

The grey species, more often termed "forester," because of its preference for the open forest lands, unlike the red kangaroo, is chiefly a coastal form. It is, however, to be found a long way from the sea—two or three hundred miles. The most of its territory, years ago, was claimed for sheep-runs and farmers, but it still lives in fair numbers in certain parts of its range—the eastern and southern portions of Australia. Gregarious, at least when feeding, it forms both small and large mobs. I have seen nearly 50 together; also five or six; and have observed, now and then, a lonely grey kangaroo—always a male.

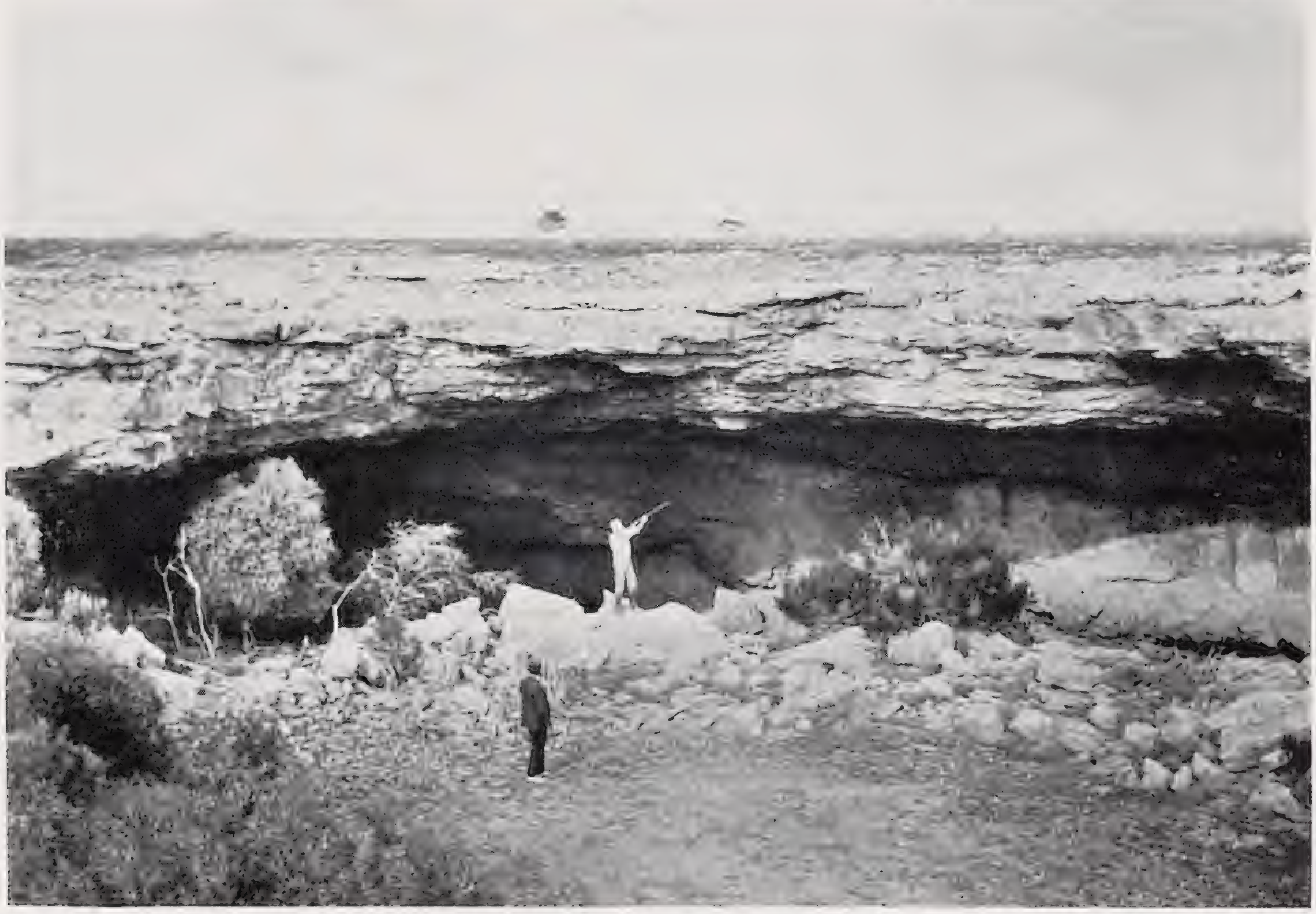
Smaller, darker, and of slighter build than *M. giganteus,* is the black-faced kangaroo (*M. melanops*). It frequents scrubland and bush, and is common in the Mallee country—that remarkable dry region, with its covering of dwarf Eucalyptus trees, its pine-ridges and sand drifts, and wonderful fauna and flora. It is in the Mallee that the mound-nest building



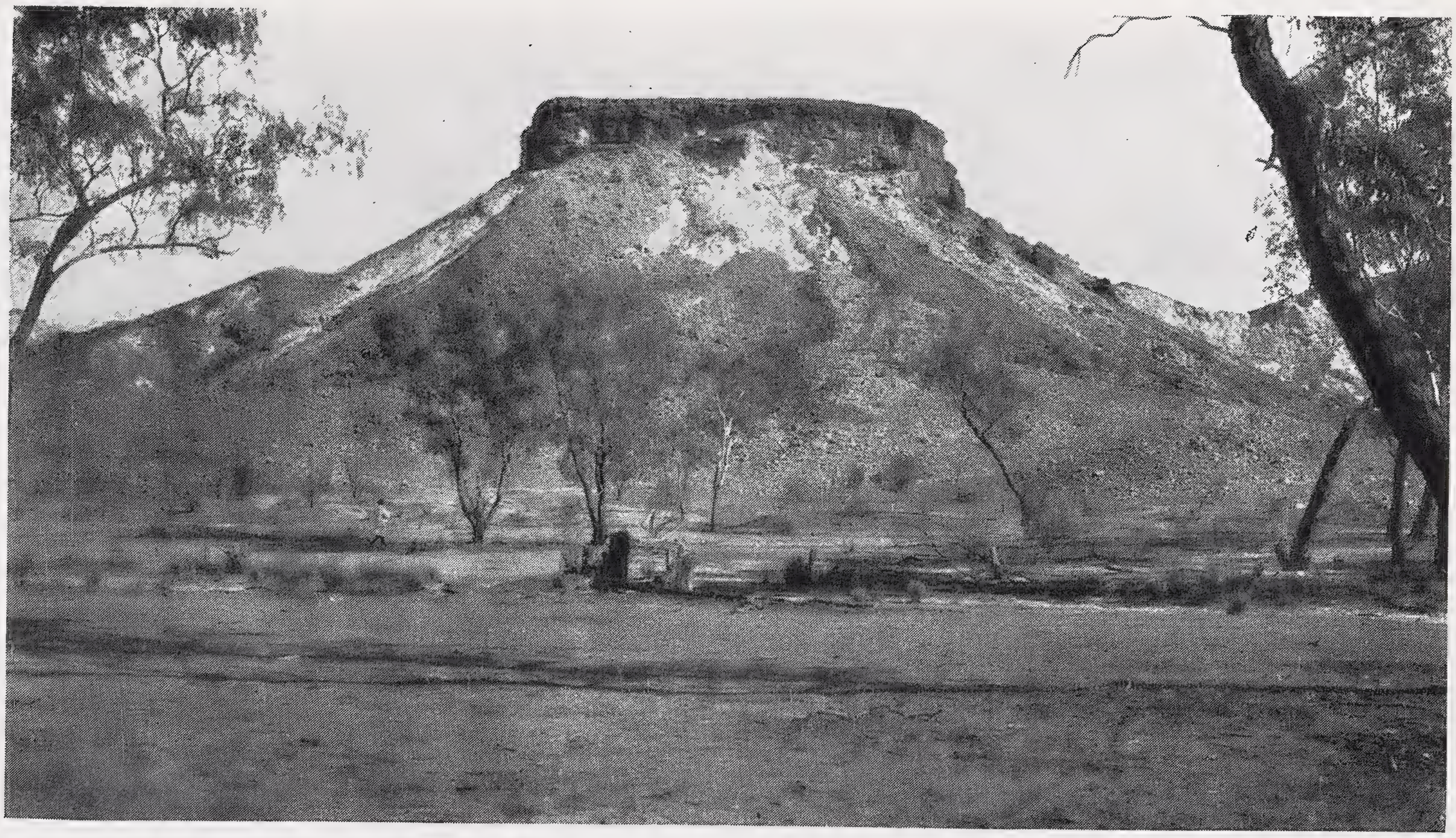
Rock-wallabies are animals that live in the rocky ranges. Some species frequent caverns, spending the daytime in such retreats. This is the typical habitat of the brush-tailed rock wallaby *Petrogale penicillata*. From a photograph by Charles Barrett.



Nullarbor Plain. A blow hole on the Nullarbor. These holes are a notable feature of the treeless plain and present a problem to geologists. Some are shallow and blocked; others deep, leading to mysterious caverns, with galleries opening from them. They are the doorways to a vast, unexplored underworld. Kangaroos frequent these great treeless and scarcely explored areas. From a photograph by Charles Barrett.



The Dingo Donga Cave on the Nullarbor Plain, known to only a few people, is the haunt of small bats. It has been their refuge for thousands of years, judging by the pyramids of guano on the floor of the main chamber, which is over 100 feet high. The cave opens off a great and deep circular "donga" with rugged walls which are unscalable except at one spot where boulders are piled in a natural stairway. Kangaroos often frequent these "dongas" in search of water which collects in rock-holes. From a photograph by Charles Barrett.



Crown Point, a famous landmark in the heart of Central Australia. Red kangaroos live on the plains of this vast inland region. From a photograph by Charles Barrett.

birds, *Leipoa ocellata,* have their ever-narrowing territory. The wilderness of little gums, of "spinifex" (*Troidia*) and sand, is rapidly being converted into wheat-fields.

Kangaroo Island, off the coast of South Australia, has its own special kangaroo (*M. fuliginosus*). Flinders, the famous navigator, and the French explorers, found the island so well stocked with the marsupials, over a century ago, that it deserved the name bestowed upon it by the English captain. It still has a population of kangaroos; they live in dense scrub, and are numerous in many places. There is a big national reserve for wild life on Kangaroo Island.

Arnhem Land, in the far north of Australia, where a great area has been reserved for the aborigines, is the realm of the antilopine kangaroo (*M. antilopinus*), a short-furred, stoutly built and heavy species. They are not numerous, and, being very shy, are difficult to observe. We know little of their ways in the wild.

The wallaroo or euro (*M. robustus*), is a mountain species; it keeps to the rocky hills and is rarely, if ever, seen on the plains. But it inhabits both coastal and inland areas, is wide-ranging, and variable in coloration. There is a rufous form, a very dark, almost black form, and a light-hued, sandy variety. Eight or nine sub-species have been described, but some are very doubtfully entitled to such rank. The systematist has been too generous.

Wallaroos are sturdy mountaineers, being thickset animals adapted to their mode of living, often in steep and rugged hills. They are more formidable than the grey kangaroo, as many dogs have found to their cost. "The wallaroos," write LeSouef and Burrell, "are determined fighters; they use their teeth more than other kangaroos, and one has to be careful in approaching old males; when hunted they make for the rocks."

When searching for aboriginal rock paintings and carvings in a wild and lonely range of hills, recently, I saw wallaroos "at home." Early one morning an old male appeared on the ridge above my camp, beside a water-hole in the rock. It gazed down for a minute, then hopped leisurely away, silhouetted against the brightening sky.

In the old days, when the blacks camped at Mottwingee rock-holes, a kangaroo venturing within range would surely have been speared. The flesh of these marsupials is not to the taste of most white men, without the sauce of hunger. But it has been praised for its flavor! Thus when John Gould, the pioneer of Australian ornithology, and his party were making a forced march, their provisions being exhausted, a red kangaroo was killed, and its flesh lasted the wanderers for four days. It was excellent food, is Gould's testimony. The animals weighed over 200 lbs. Kangaroo-tail soup is not to be despised, though perhaps one must learn to like it.

The Wallabies: — Wallabies are merely smaller kangaroos and are not markedly distinguished from their big near-relations, despite minor external and structural differences. There are numerous species, and to deal with them all would be wearisome. They are not, as a rule, gregarious, although often one finds many of a species congregated. On an island in Bass Strait, in a small patch of scrub, remaining very still, I was surrounded by wallabies. When I moved, suddenly, dozens of the animals went pounding away through the bushes. It is usual to see wallabies in pairs, or singly. They avoid being out in the open, because of the danger from their enemies. The dingo and the fox prey upon wallabies; so does our great eagle, the second largest eagle in the world, powerful enough to bear aloft a small wallaby in its talons.

Wallabies frequent the Mallee scrub, lightly and heavily timbered country, scrubby hills, and the sub-tropical and tropical "brushes" where palms grow tall and orchids tuft the branches and trunks of splendid "rain-forest" trees. You may follow wallaby tracks through scrub and jungle. In the glades, towards evening, it is pleasant to see wallabies feeding, or standing at gaze in their own charming manner. Delightful creatures, even at the Zoo; in their natural haunts, they are still more engaging.

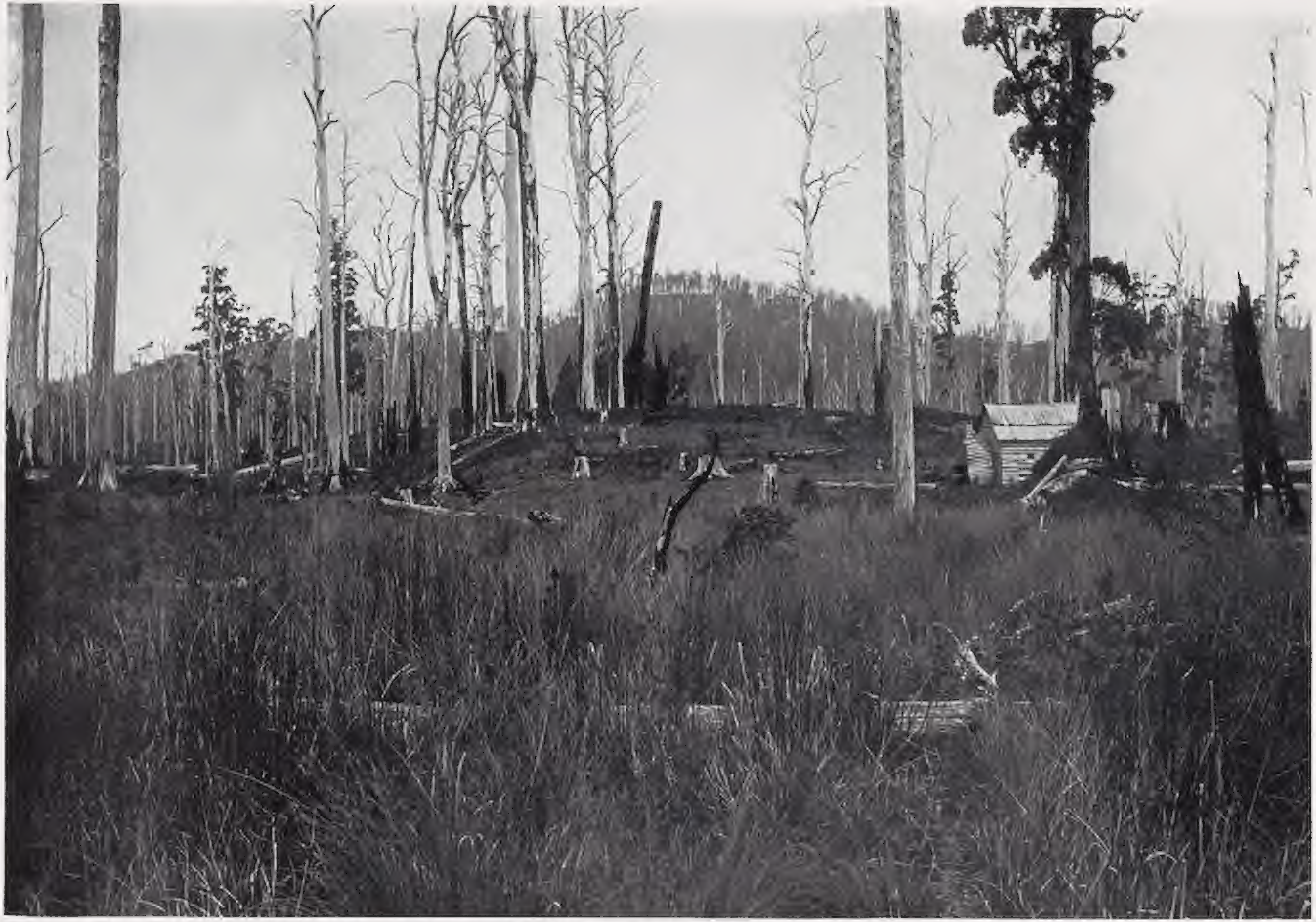
In wide-ranging species, there is considerable color variation. The black-tailed wallaby (*M. ualabatus*) is lighter colored in its northern habitat than in the south—it ranges from my own state, Victoria, to northern parts of Queensland. It exists in large numbers in the south, where it is regarded as fair game by the sportsman and is hunted for the sake of its pelt. Big bundles of skins are commonly seen in the skin stores, and the export trade is extensive.

Victoria's Mallee Park. An area of over 30,000 acres has been set aside as a sanctuary for gray kangaroos and other native animals. From a photograph by Charles Barrett.

Grey kangaroos in the Zoological Gardens of Melbourne, Australia.
From a photograph by Charles Barrett.

In the Federal Territory. A view near Canberra, the capital of the Commonwealth. Kangaroos inhabit the distant lowlands and wallabies live in the far distant ranges. From a photograph by Charles Barrett.

The entrance to a shallow limestone cave in western Victoria. Many fossils of giant extinct kangaroos were found in this cavern. From a photograph by Charles Barrett.



A scene in Tasmania. The home of a pioneer on the edge of a great, swampy area. Some of the smaller wallabies frequent these marshy areas, the tall water-loving grasses and ferns providing a safe shelter for these timid animals. From a photograph by Charles Barrett.

In size and shape the members of this group, the large wallabies, are much alike. With hind feet relatively large, they are more powerful jumpers than the smaller wallabies. Compared with kangaroos, they are brightly colored animals.

Brush wallaby is the popular name for the red-necked species (*M. ruficollis*) which, especially for this article, I photographed, in a paddock at the Melbourne Zoo, while its near ally, Bennett's wallaby (*M.r. bennettii*) came hopping up, inquisitively. The latter belongs to Tasmania.

For grace and beauty, Parry's wallaby (*M. parryi*), of northern New South Wales and Queensland, ranks first perhaps, in the "large" group. It sometimes is called "pretty face," because of white and grey markings on the face. Its tail is exceptionally long, and it has a slender body. A dweller on the highlands, it is to be looked for in fairly open country. You may gain long distance views of Parry's wallaby, but to approach it closely is not easy. It has a remarkable turn of speed, and is away in a moment when startled.

Another species with conspicuous markings, but on the thighs, not the face, is the black-striped wallaby (*M. dorsalis*), of the interior of New South Wales and Queensland. The black-gloved wallaby (*M. irma*), of south-western Australia, is dark bluish-grey above, with yellowish grey underparts. Its fingers and toes are black "gloved," and the tail is crested with stiff hairs, black, like the paws. This is an abundant form, found chiefly in the open forest lands.

The beautiful, short-eared agile wallaby (*M. agilis*), belongs to the tropical north, occurring also on certain of the islands and in Papua. I have seen it only once, at large, and was charmed by its delicate coloring—light fawn—and graceful appearance. It frequents country where the grass grows tall, and is conspicuous, with its uniform light coloration. This is the only member of the large wallabies group inhabiting Papua.

About a dozen species comprise the small wallabies group. They are much persecuted by the trappers, their fur being beautifully soft and of fine texture. They range far into the tropics, one species occurring on the Aru Islands; another in New Guinea and the New Britain group. They are mostly shy in disposition, being dwellers in dense scrub, or some class of "cover" where they are much more often heard than seen. Some kinds, towards sundown, or later, appear on the edge of the jungle or the forest. It is feeding time for wallabies when the shadows are long.

The Cape York wallaby (*M. coxeni*) is short-furred and sandy-colored or grizzled, with white under-surface. It is similar in coloration to the agile wallaby, also a northern form, and it has been suggested that this similarity may be the result of adaptation to environment. Other members of the "small" group are the banded wallaby (*M. stigmaticus*), the red-legged wallaby (*M. wilcoxi*), the Aru Island wallaby (*M. brunii*), the sombre wallaby (*M. browni*), the Parma wallaby (*M. parma*), and the rufous-bellied wallaby (*M. billardieri*), the last named being the common species of Victoria and Tasmania: it is abundant.

The non-naturalist generally terms any small wallaby a "pademelon." The name belongs rightly to *M. thetidis*, of south-eastern Australia. It is numerous in scrub-covered country. Many a pademelon have I startled on my bush rambles; and sometimes myself have been surprised by one, suddenly thumping off through the scrub, its presence the minute before unsuspected.

Rock Wallabies:—There are twelve species of rock-wallabies, forming the genus *Petrogale*. They are wonderfully agile, and live in rocky ranges, throughout the continent, but are absent from Tasmania. Some are cave-dwellers, and among the most interesting of marsupials. They form paths among the rocks, trails which they follow at high speed, though to the human eye not clearly defined, at least in places. Their toes are adapted for rock-climbing, being rough with small tubercles, which give a grip even on surfaces worn smooth by the feet of many generations of rock-wallabies.

Their foe is the fox, in parts of their range; in many localities, toll is taken of rock-wallabies by the Australian python (*Morelia variegata Gray*), known as the carpet-snake. This reptile is plentiful in *Petrogale* haunts, lurking in the caves. It attains a length of fourteen feet, but the average specimen is much shorter.

Central Mount Stuart. This peak is practically the center of Australia. On the plains about this region is the habitat of the great red kangaroo *M. rufus.* It is met with in small "mobs" and is the characteristic kangaroo of the central country. From a photograph by Charles Barrett.

The rock-wallaby is noted for its agility and boldness, and accuracy in jumping. It climbs leaning tree-trunks, and leaps from rock to rock as nimbly as a chamois of the Alps. Among the species are the brush-tailed rock-wallaby (*P. penicillata*), the yellow-footed rock-wallaby (*P. xanthopus*), and the short-eared rock-wallaby (*P. brachyotis*), which inhabits the north-western coast of the continent.

Nail-tailed Wallabies:—The genus *Onychogale* contains the three species of nail-tailed wallabies, characterized by the small horny spur at the tip of the tail, and also the form of their incisor teeth. What the use of the nail-like appendage is, we can only conjecture. The best-known species is the bridled nail-tailed wallaby (*O. frenata*), of eastern Australia, where it frequents ranges of low hills and long-grass country. It is seldom met with nowadays, owing to the advance of settlement and ravages of that introduced "curse," as we often term, justly, the European fox.

Other Wallabies:—The banded wallaby (*Lagostrophus fasciatus*) is an inhabitant of Western Australia, dry areas on the mainland, and some of the islands.

The little hare-wallabies deserve their descriptive name, for their speed, when pursued, is amazing; while they also possess remarkable powers of leaping. Both in size and form, these very active marsupials recall the common hare of Europe. The common hare-wallaby (*L. leporiodes*) inhabits the interior of New South Wales and South Australia.

The *Dorcopsis* wallabies are small and dull-colored animals, confined to New Guinea. There are eight or nine species.

Tree-Kangaroos:—Romance might have a chapter in any book dealing with the tree-kangaroos. They need a volume to themselves, if only a small one could be written. The discovery of each species, the quests for specimens for Zoological gardens, descriptions of tree-kangaroo country—would form subjects for descriptive writing by a literary naturalist.

I have been in the haunts of the two Australian species of *Dendrolagus,* and have what probably are unique photographs of a New Guinea form. Ambition may take me again on the trail of *Dendrolagus,* in our tropical wilds.

No fewer than fourteen species of *Dendrolagus* have been described, all but two being found in New Guinea. Some are very attractive, and make delightful pets; others are coarse-furred and have, in captivity, sleepy-looking faces. All are dwellers on the mountains, or at least in high places; their haunts are remote from settlement, and in the wildest class of country. They choose the most inaccessible places, usually near the mountain summit.

Tree-kangaroos are not wholly arboreal in their habits; on the contrary, they spend much time on the ground, climbing trees when in danger from dogs or other enemies, and for the purpose of feeding. These notes refer to the Australia species, of which we have the most knowledge—it is scanty enough! But doubtless, the habits of the New Guinea tree-kangaroo are much the same as those of their Australian allies.

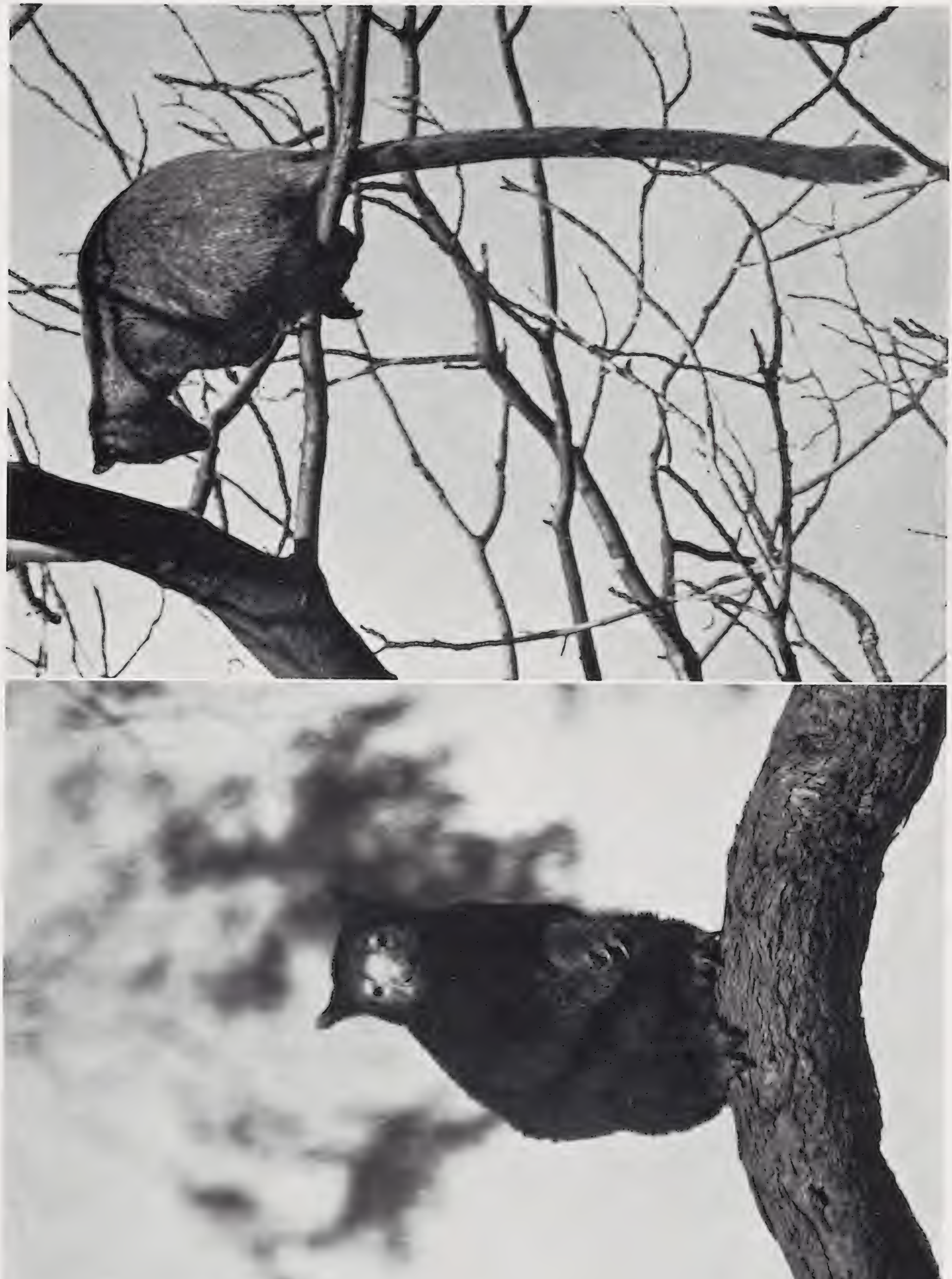
All the species are well adapted to the arboreal mode of life. Their foot-pads are much roughened; their claws are thick and strong and sharpened; those of the two outer toes are as much curved on the hind- as in the fore-foot. The tail, which serves well as a balancer among the boughs, is very long, with hair thick and even. The fore-limbs are nearly as long as the hinder ones and remarkably stout and strong.

These members of an essentially terrestrial sub-family, apparently have acquired larger and more powerful fore-limbs than any other kangaroos, as a result of arboreal habits. Or it may be, as Lydekker mentions, a primitive feature. That great naturalist, however, was inclined to favor the former view.

Tree-kangaroos are at ease among high and fairly slender boughs, but often climb low trees. They leap to the ground, often from a great height, alighting on their feet, as safely as a cat does after jumping, and running rapidly away. Leaps from about twenty feet up are not unusual, while one may be made even from a height of sixty feet!

The Lumholtz tree-kangaroo (*D. lumholtzi*), whose realm is among the ranges of north-eastern Queensland, with its black face and chin, black toes, fine grizzled-grey general color, white chest and pale yellowish-white under-surface, is one of the most beautiful Australian animals—a pleasure to the eyes of any naturalist. Its discoverer, the late Carl Lumholtz, was overjoyed when his long search for the

A view in the mountainous country in northeastern New South Wales. The pademelon *M. thetidis* and other species of the small wallabies are found in this type of country. From a photograph by Charles Barrett.



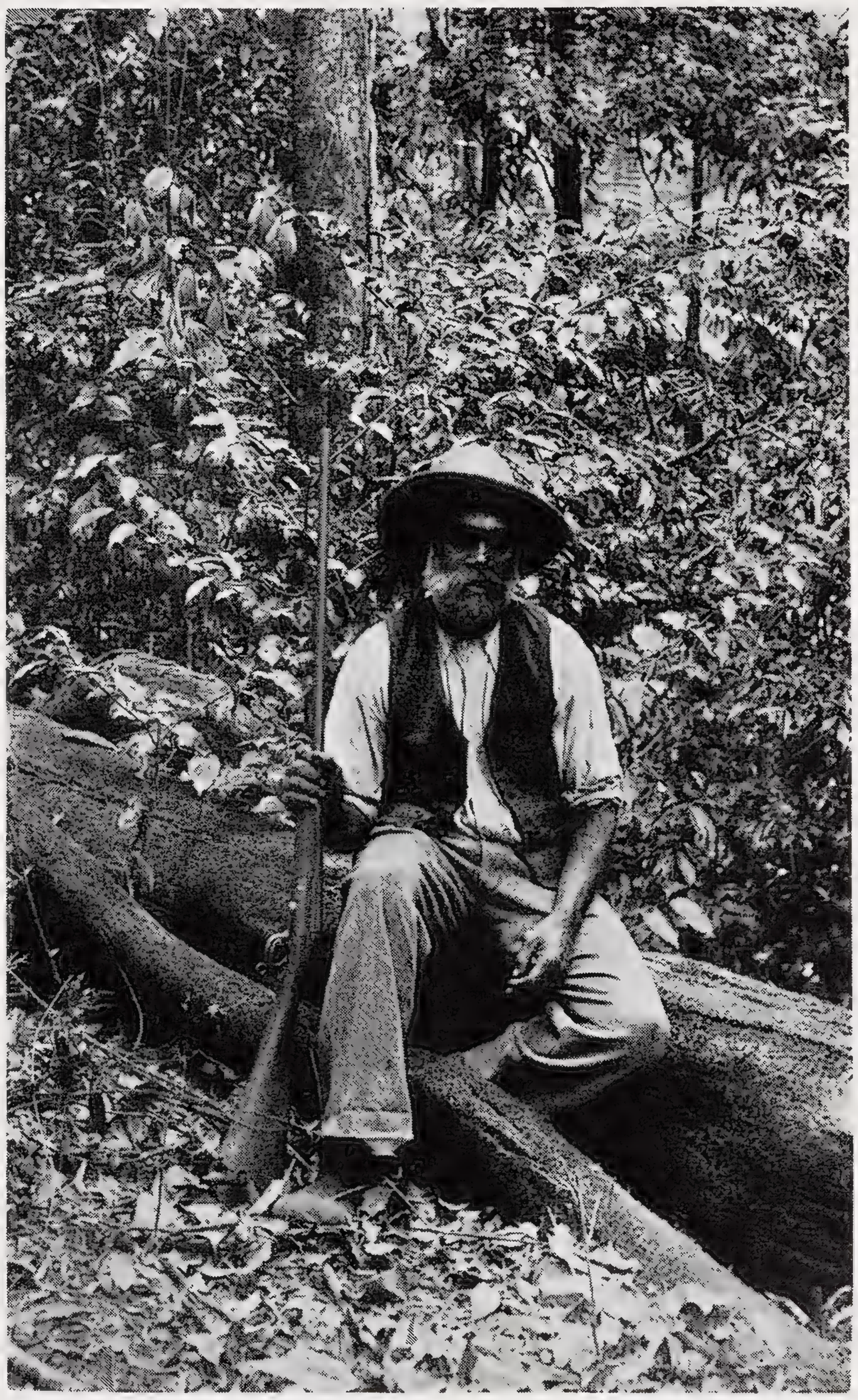
Left. The New Guinea species of tree-kangaroo *D. matschiei.* From a photograph by Charles Barrett.
Right. Bennett's tree-kangaroo. The picture gives an admirable idea of the use of the tail as a balance.
From a photograph by the late D. Le Souef.

"boongarry" of the aborigines was at last rewarded. He didn't forget to be generous to his cannibal guides and friends. One native received a shirt, another a handkerchief, while all received an extra allowance of food and tobacco.

That was long years ago. When I visited the "boongarry" country, in 1928, there were few aborigines there, and none was a cannibal! Cannibalism now is as a tale that is told, among the blacks of the Herbert River district. Much of the country has been cleared and cultivated. But farther afield I was in a wild and little-known region. My headquarters were on the Daintree River, where, in a morning's "run" down stream aboard a launch or a lugger, you may see ten or a dozen crocodiles. They bask on the mud-banks and lurk among the mangroves. Blue peaks in the distance lured me—the range where tree-kangaroos live.

It was my fortune to see only one specimen, captured near a mountain top, by bushmen. Money could not buy it. *Dendrolagus* was hard to get, and worth keeping, I was told.

Bennett's tree-kangaroo (*D. bennettianus*) was described from the Bloomfield River district, north-eastern Queensland. It was observed in its haunts by my late friend, Mr. D. LeSouef, who obtained 16 specimens for the Melbourne Zoological Gardens, of which he was for so many years the Director. I saw the animals often, climbing or perched on boughs of the tree in their enclosure. They lived happily enough for a time; but, one by one, died, until *Dendrolagus* was unrepresented at the Zoo. Tree-kangaroos rarely survive capture for any length of time. The New Guinea species, shown in my photograph, lived for less than a year after reaching Melbourne.



Ancient and modern hunters. *Upper:* Old time aborigine, in full dress, casting a spear with a throwing stick. The blacks are clever spearsmen. *Lower:* A modern hunter in civilized dress who uses a gun. This aborigine was once the author's guide in the wilds of Queensland. From photographs by Charles Barrett.

A jungle path in the forest of North Queensland. In this forest region is the haunt of the Lumholtz tree-kangaroo. From a photograph by Charles Barrett.

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BULLETIN
NEW YORK ZOOLOGICAL SOCIETY

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THE KOALA .... *Cover*

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BULLETIN

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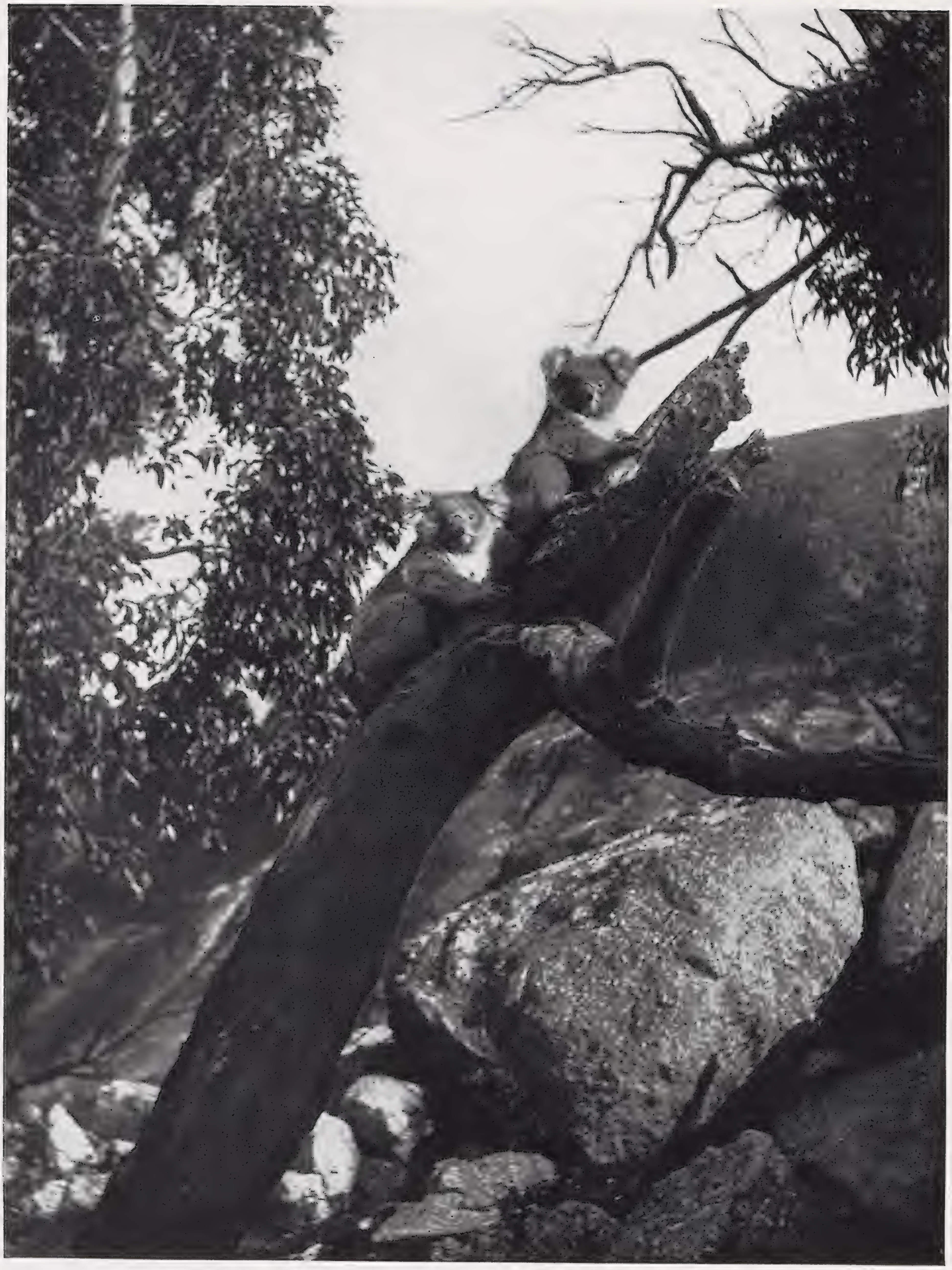

The koala is a poor climber. Its hind feet are admirably adapted for climbing, but possibly because it lacks a tail, its progress is painfully slow. It is not for lack of practice, since it spends the greater portion of its life at lofty heights in gum trees, the leaves of which being almost exclusively the sole diet. Except for an occasional meal of roots, it is gum leaves or nothing else. No other food will answer, and even with an abundance of the latter, the koala is not easily kept alive in captivity in its own land. Photograph by Charles Barrett.

BULLETIN
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Some Australian Marsupials

Raymond L. Ditmars
Curator of Mammals and Reptiles, Zoological Park

A brief introduction to the various marsupial forms that have been exhibited in the Zoological Park, together with a short account of the Koala, the "Native Bear" of Australia, by Charles M. Barrett. Illustrations for the Koala were made by Mr. Barrett as indicated under the cuts, and the other illustrations were made from the collections in the Zoological Park.

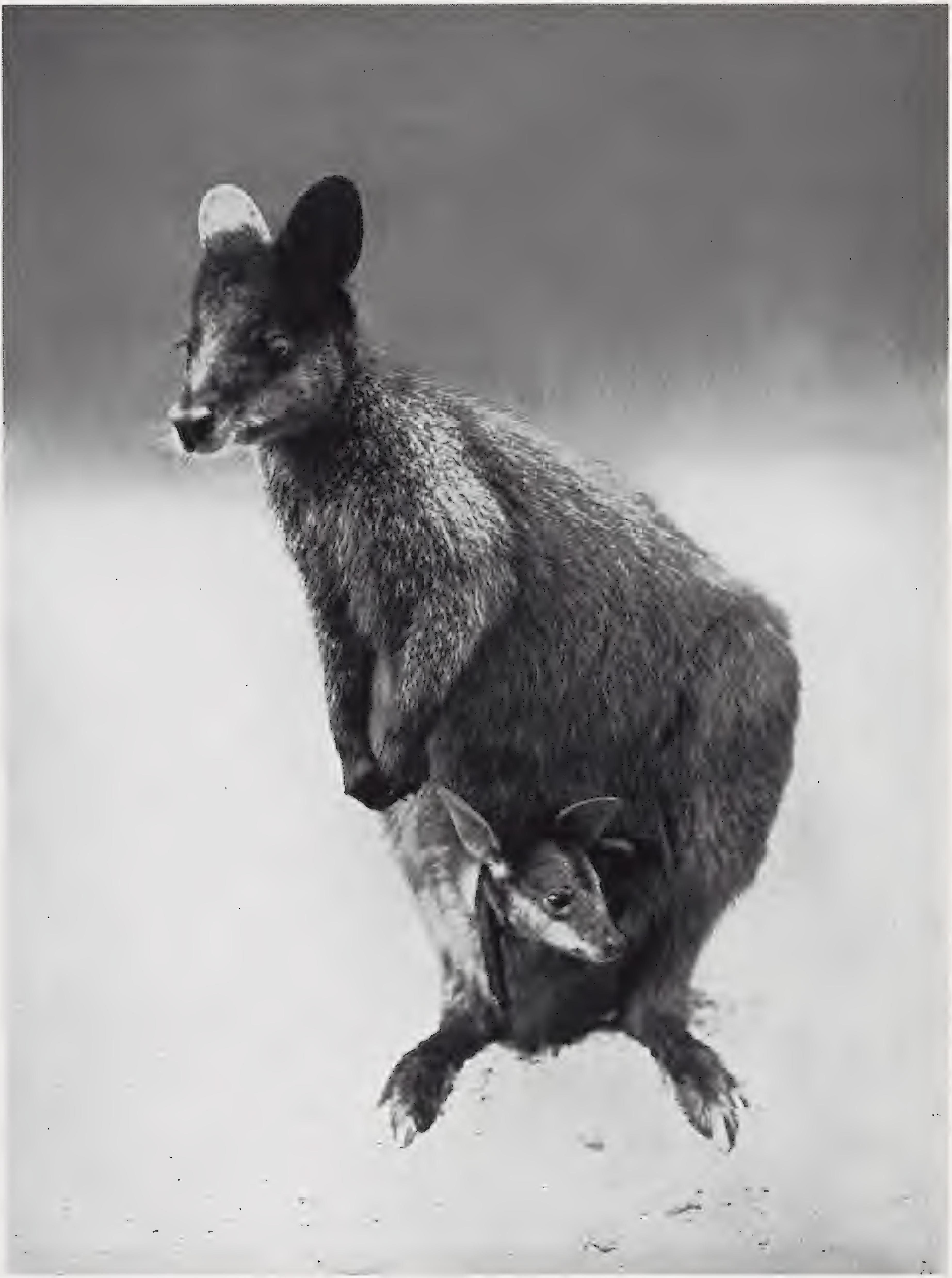
AUSTRALIA has a mammalian fauna markedly different from all other continental areas, from several points of view. The most striking feature is the absence of species of the various orders so abundantly represented on other tropical and temperate land areas in various parts of the world. There is but one native carnivore (the dingo), and there are no native hoofed animals. There are less than two dozen species of rodents, these of rather monotonous development. Representatives of the Insectivora are lacking. The second remarkable condition rendering the island-continent unique, is the abundance and variety of form and size of the Marsupialia, or pouched animals, which in other parts of the world are but scantly represented. What is true of Australia is largely true of New Guinea, and to the south, Tasmania and even New Zealand, between all of which there appears to have been land connections in remote times.

Another point worthy of note is the sole occurrence of an order of egg-laying mammals, remnants of the most ancient and primitive of the mammals of the World. It is indicated that these forms have not only survived but that they originated in Australia.

The point of most striking interest among the mammals of this area is the development of the marsupials, large and small, into specialized forms to "match" species of unrelated orders. This remarkable parallelism is carried to such an extent that, despite the absence of other orders of mammals, the Australian marsupials present a versatility of form to amply take their place. Thus the kangaroos and wallabies take the place of deer and antelopes on the plains; the phalangers are like squirrels in the forests; some even having developed scaling planes like the flying squirrels. The wombat is like a big woodchuck, even to the broadening of incisor teeth for cutting; there are marsupial "rats and mice," a pouched wolf, marsupial "cats" and weasels, the masquerade having radiated to the extent of varied forms to include those like moles and anteaters to parallel insectivores and edentates.

With a fauna like this from which to draw for zoological exhibition, scientific institutions specializing in living specimens have naturally long been keen in procuring specimens from Australia. Such has been the case with the Zoological Park, and we have been particularly fortunate in maintaining representative series of mammals from Australia and adjacent land areas. The most familiar of these mammalian forms, of course, are the kangaroos, which are found nowhere else in the world.

The elaboration of species of kangaroos is not generally known. Including the kangaroos and wallabies—the larger and smaller kinds—approximately three dozen species of these



A black swamp-wallaby carrying her young in the marsupium, where, from the time of its birth, it spends at least six months before it begins to forage on its own account. But one is produced at birth. A tiny bit of life less than an inch in length and so thoroughly undeveloped that it might puzzle a scientific scholar to give it classification. The immature young is placed in the marsupial pouch by the mother and the feeding from that time is purely mechanical and at the will of the parent. Various theories have been advanced concerning this function, but the one mentioned seems most plausible, considering the very helpless state of the young one at birth. There are some three score members of this family, all found in Australia and the closely adjacent land areas.

unique animals occur in Australia. These are divided into eight distinct genera. The species vary in size from a body length of about twelve inches—creatures which hop along like a rabbit, and of similar habits to that type—to the Giant Red Kangaroo inhabiting the plains of the Murray Basin, which lives in herds, is in excess of five feet in combined length of head and body, and when reared upon its powerful jumping legs can stand higher than the average human. Specimens of the Giant Red Kangaroo, the Great Gray Kangaroo and the equally powerful Euro Kangaroo or Wallaroo, have been on exhibition in the Zoological Park for a long time. These creatures consume the same food and require similar care to hoofed animals. Our collection of kangaroos was started in a series of stalls in the Small-Deer House, but the title of that building has become a misnomer. The collection has so increased by purchase and breeding that the structure is now given over to the exhibition of kangaroos and wild swine.

The carnivorous marsupials are of great interest. Largest among them is the so-called Tasmanian Wolf, *Thylacinus cynocephalus,* approaching in dimensions and form a true wolf, and certainly resembling the latter in habits. It hides in caves during the day, hunts at night, has keen scent, and preys upon the wallabies and smaller mammals, also committing depredations among the sheep belonging to settlers. The body is gray, with a series of blackish cross-stripes on the posterior two-thirds. The species is confined to Tasmania.

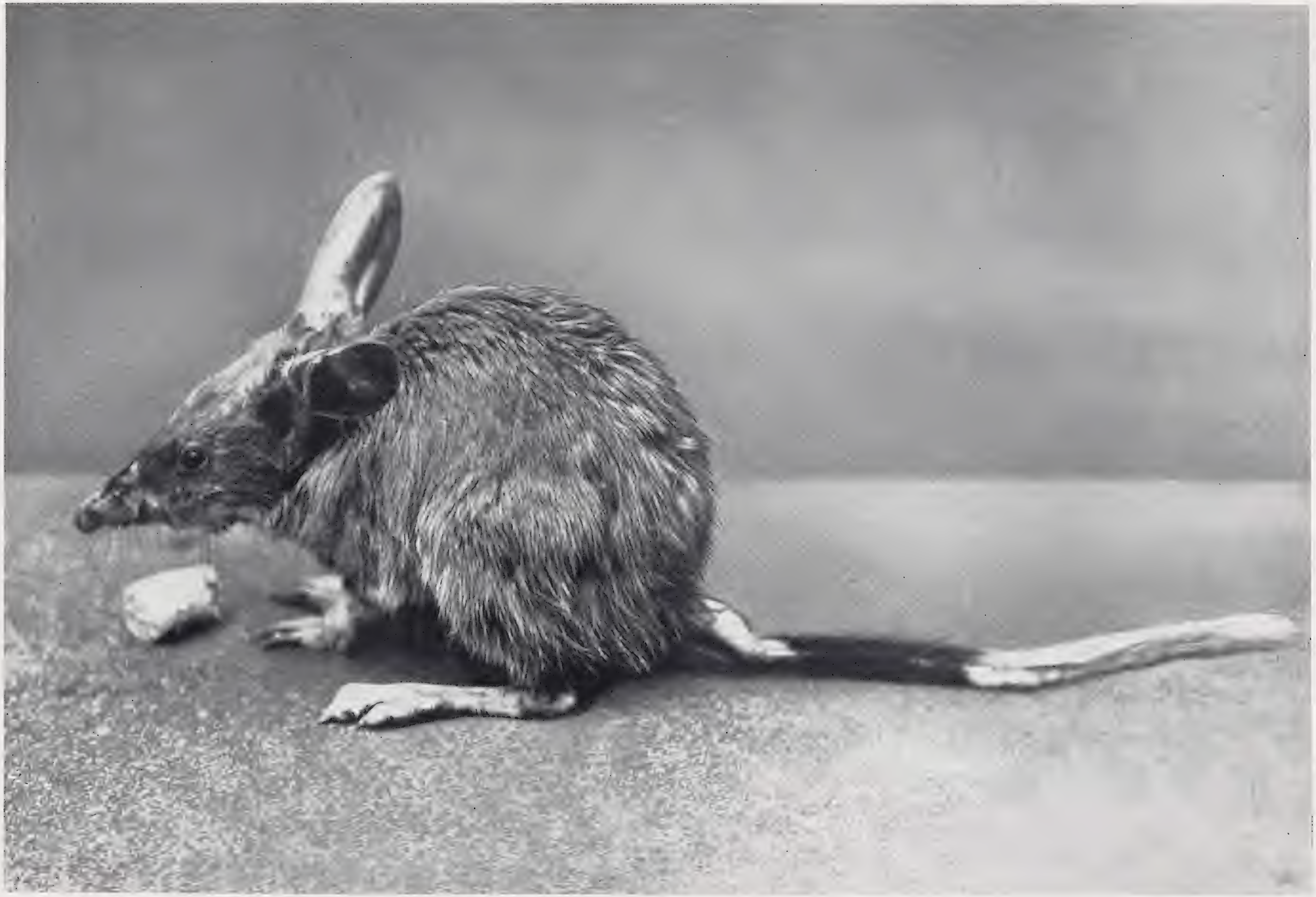
Strangely enough, Tasmania has another characteristic marsupial, the Tasmanian Devil, *Sarcophilus ursinus,* now becoming rare in all but the wildest country. This animal is of approximately the size and form of a small and stocky bull terrier. Its head, however, while proportionately very broad posteriorly, extends forward in rather pointed fashion in the excessive development of deep and very powerful jaws. By comparison with the animal's size, the crushing force of these jaws is quite astonishing. The animal can split large bones to obtain their marrow contents. It is a savage fighter, more than a match for any but a large dog, and in the past has proven very destructive to poultry and sheep. It remains savage as a captive.

The Dasyures or Australian "Native Cats" (*Dasyurus*) are in form a parallel composite of feline and civet. There is a fair series of species, most of them prettily marked with white or yellow spots on a dark gray or blackish ground. The average length is around eighteen inches for head and body, and twelve inches for the tail. They commonly occur in easterly Australia and Tasmania. These animals are strictly carnivorous and frequently raid poultry yards. They are expert climbers and live in the trees as well as on the ground.

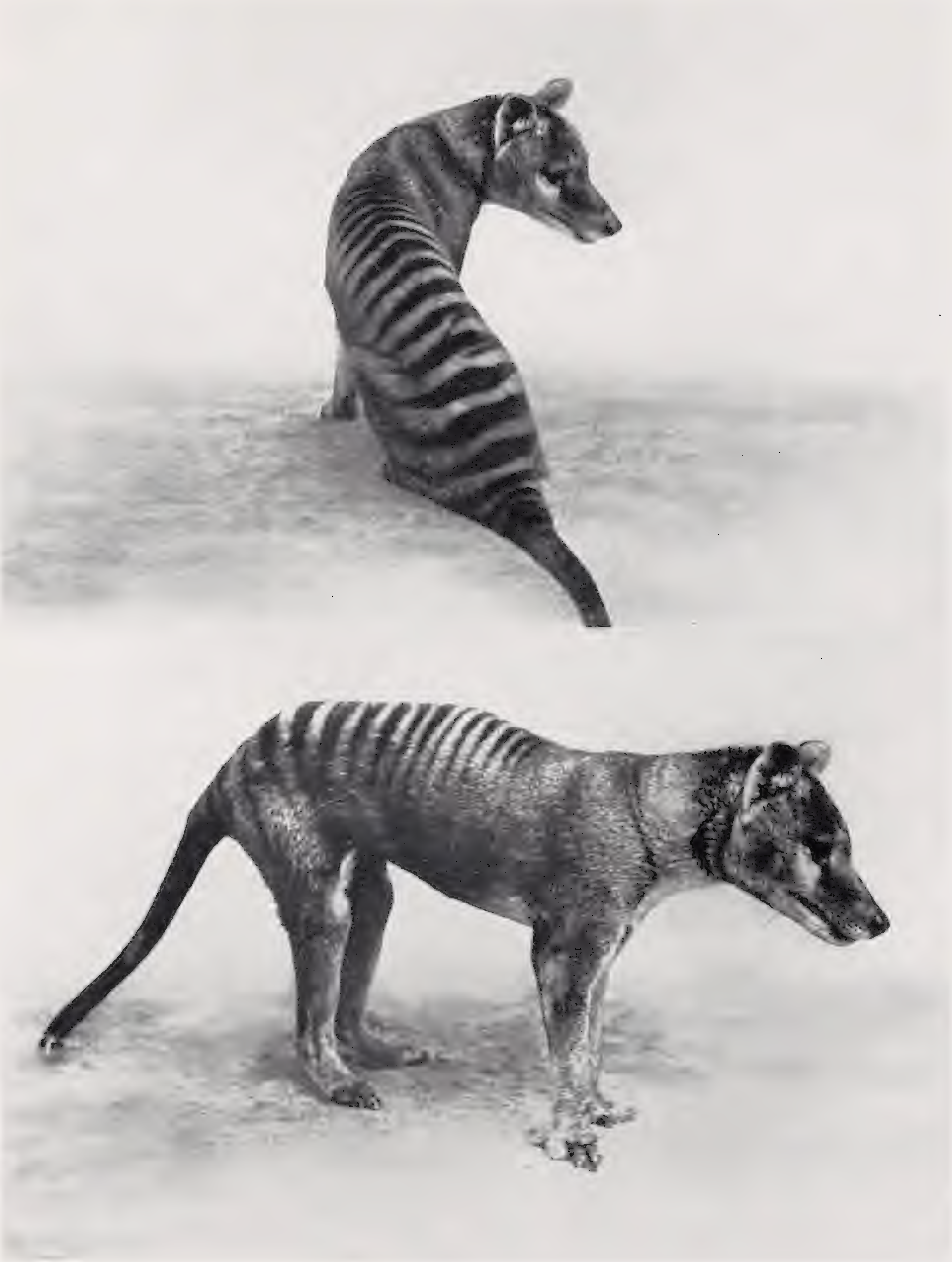
In building up a representative collection of Australian marsupials, the forms paralleling rodents should be well represented to indicate versatility of form and habits among the smaller kinds. Some are extremely difficult to obtain. Mr. Ellis Joseph, a resident of Australia, has at odd times brought us a number of rare specimens.

Largest among the pouched rodent-like forms, is the Wombat, *Phascolomys mitchelli.* This thick-set creature is tailless, and a big specimen will have a head and body over forty inches in length. Here is a replica of the marmot or the woodchuck, but grown out of bounds. Large examples weigh well over fifty pounds. The incisors have undergone specialization to the extend of looking quite like the powerful gnawing teeth of the typical rodent. The creature lives in burrows, digs rapidly with powerful claws, and is altogther herbivorous. Another "rodent" type is the Thick-tailed "Dormouse," which, with the exception of the stout caudal appendage is astonishingly like members of the European dormouse genus. They curl into a ball to hibernate, like those creatures. The Feather-tailed Flying "Mouse," *Acrobates pygmaeus,* is also called the Pygmy Flying Opossum, although it is decidedly mouse-like. There is distensible skin between the limbs, and the tail is so furred that it looks like an elongated feather, appearing to function as a rudder in guiding the animal's scaling flight.

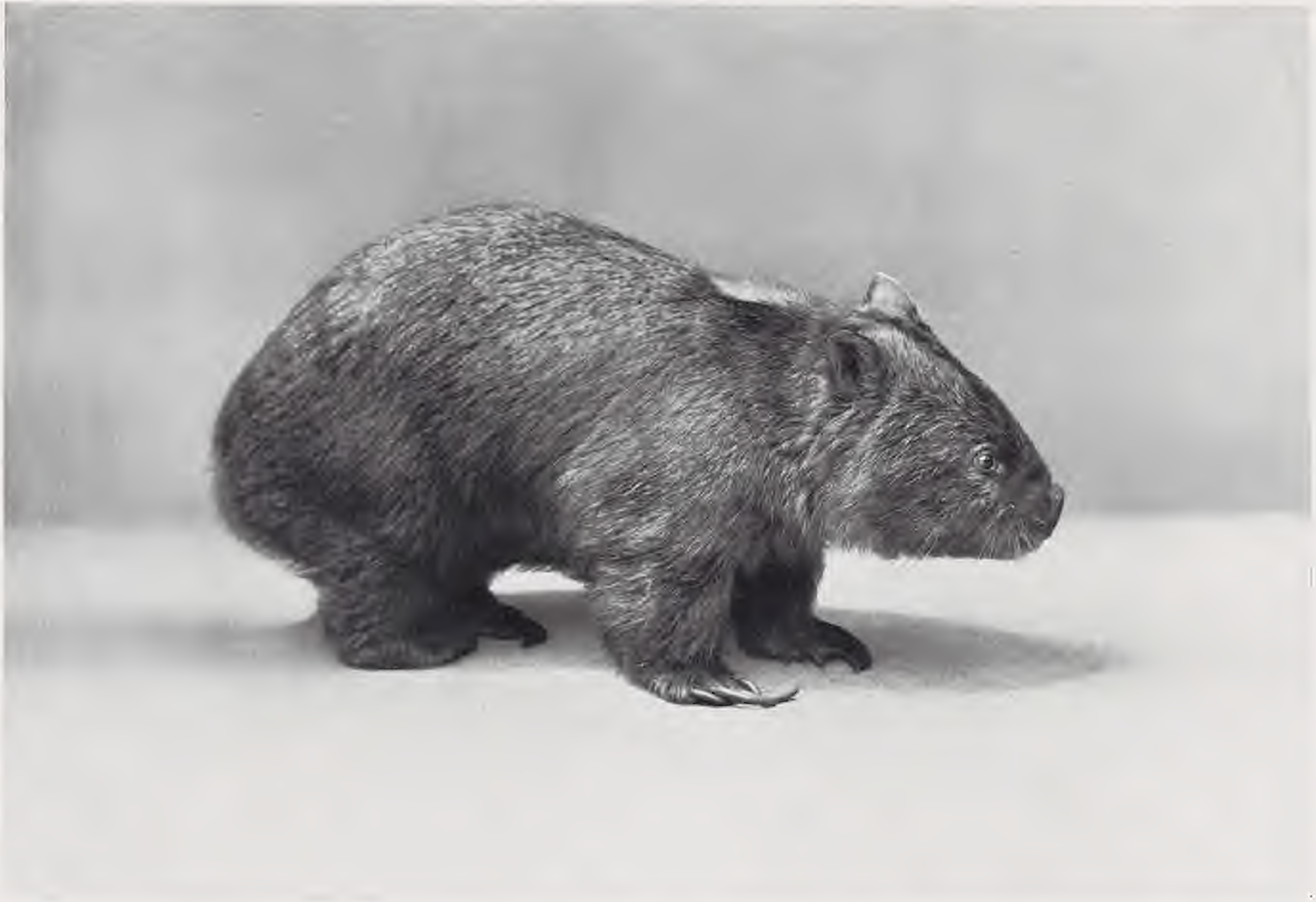
The phalangers, commonly called Flying Opossums, genus *Petaurus,* are replicas of large flying squirrels in form, and have extensive areas of elastic skin between fore and rear limbs, for gliding. These are particularly pretty animals, with very soft and deep pelage, silvery gray, and with striped head markings. The eyes are large and luminous. Closely allied to the flying phalangers are the typical Australian



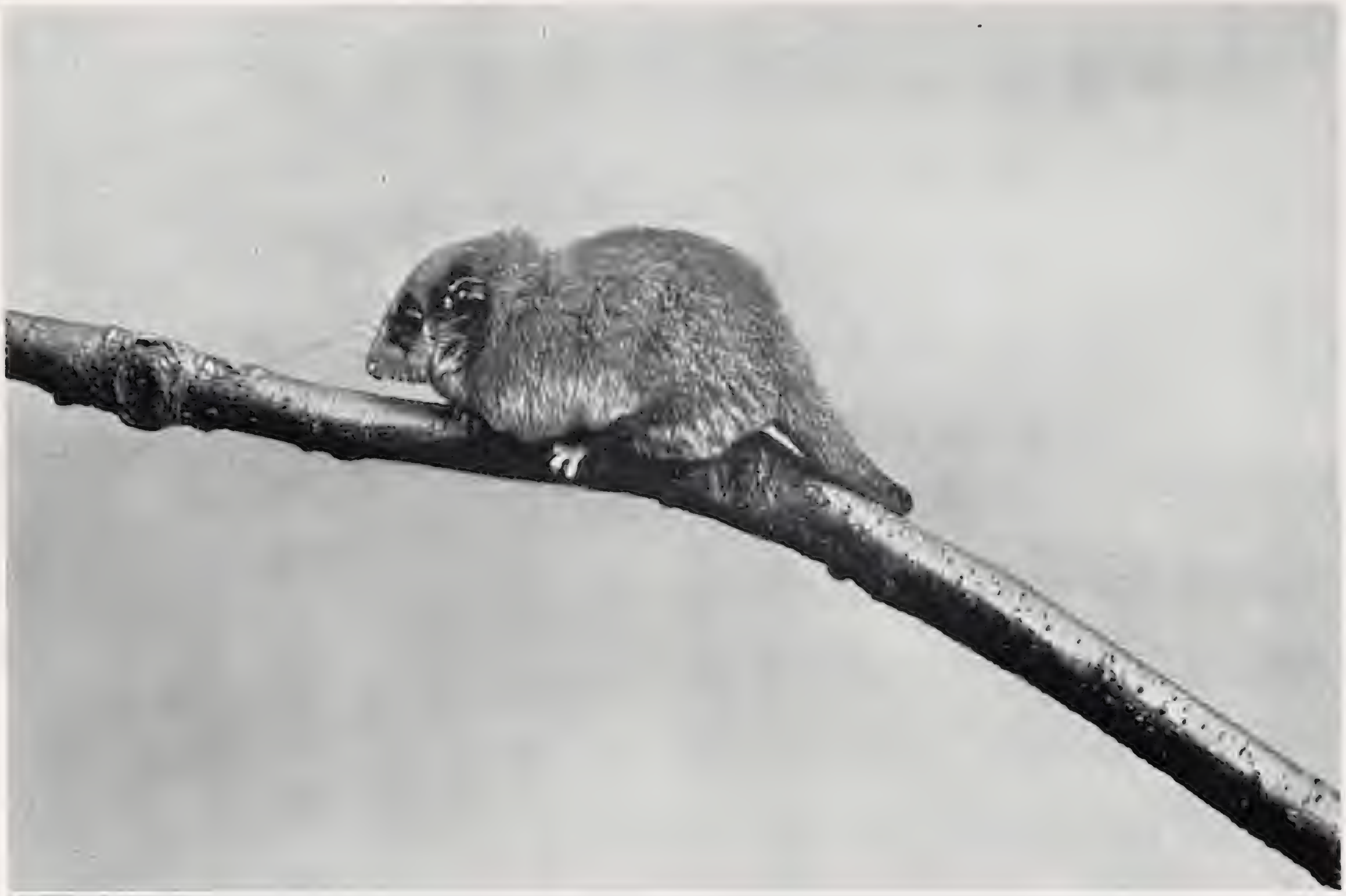
The bandicoots are graceful little animals, although they have rather an attenuated structure. There are eight or more species in Australia and several others in New Guinea. The tail is long, but not prehensile, and the marsupium opens in the opposite direction to that of other marsupials. They are burrowers and feed on insects and are partial to larval forms found on acacias, and consume at certain seasons great quantities of roots. The female usually produces two young at birth.

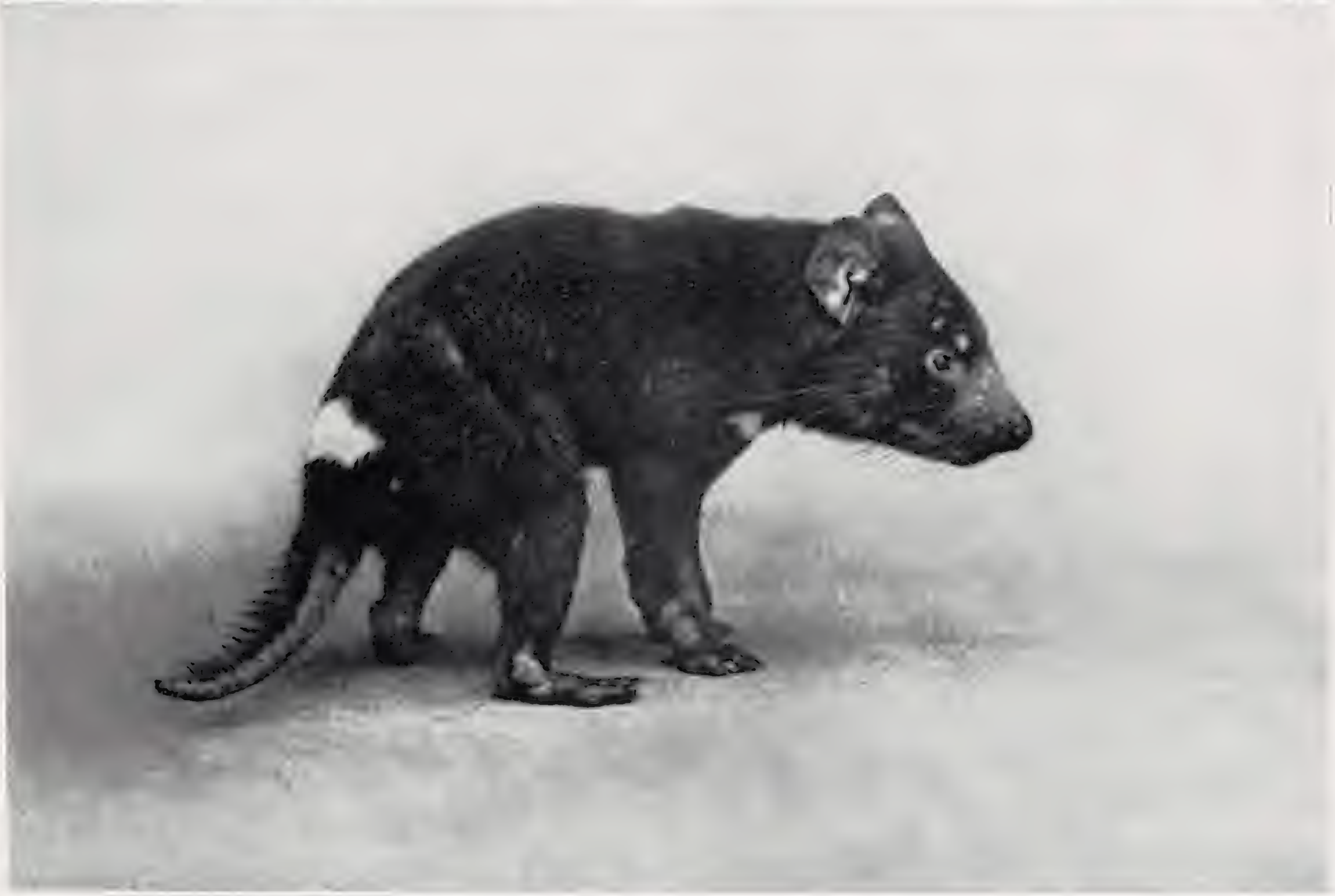


The thylacine, variously called wolf, hyena, tiger and zebra, the last names derived probably from the transverse black bars, sixteen in number, on its crupper, is a large and handsome animal confined to Tasmania. This largest of the carnivorous marsupials measures, when full grown, with the tail, nearly five feet in length, and has a very long muzzle and powerful jaws. He is nocturnal in habit, and is ill at ease in the glare of the sunlight, blinking like a distressed owl. The thylacine hunts in solitude and not, like wolves, in packs. The pouch easily accommodates the four young, which is the actual number at birth.

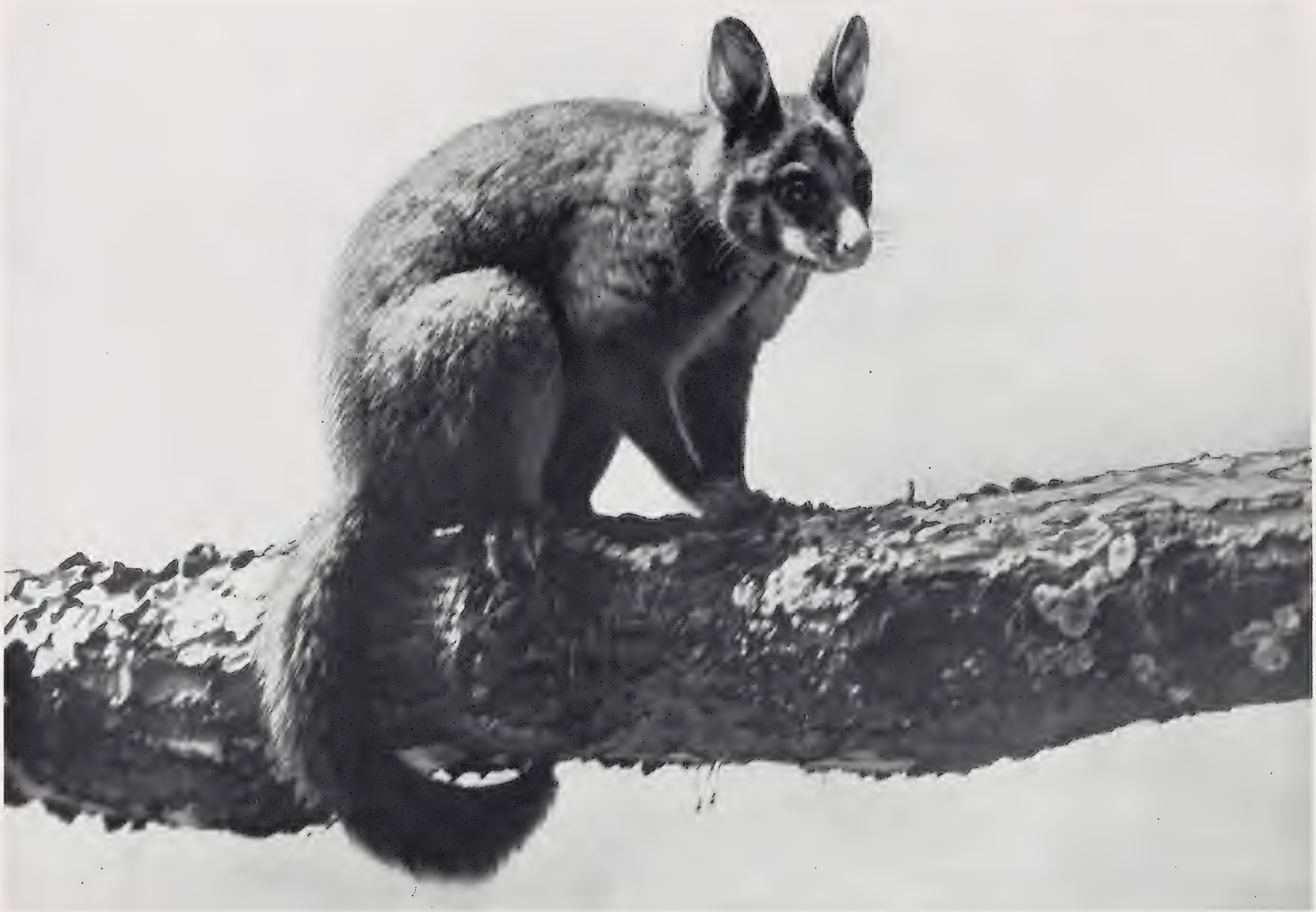


The wombats are burrowing animals and have been termed the badgers among the marsupials, to which they bear some resemblance. The wombat is a lusty digger and the damage he can do among roots is prodigious, as he has the assistance of short, powerful legs, armed with eighteen curved claws and twenty-four effective sharp teeth, although they have no roots. The bulk of the animal, compared with the short legs and small feet, is striking. The weight of sixty to seventy pounds is seemingly out of proportion to his means of supporting it. Despite his bulk, he can run swiftly, but can neither leap nor climb. It reproduces its young slowly, usually one at a time. The only sound it is capable of making is a peculiar hiss when irritated. There are two species, one found in Tasmania.

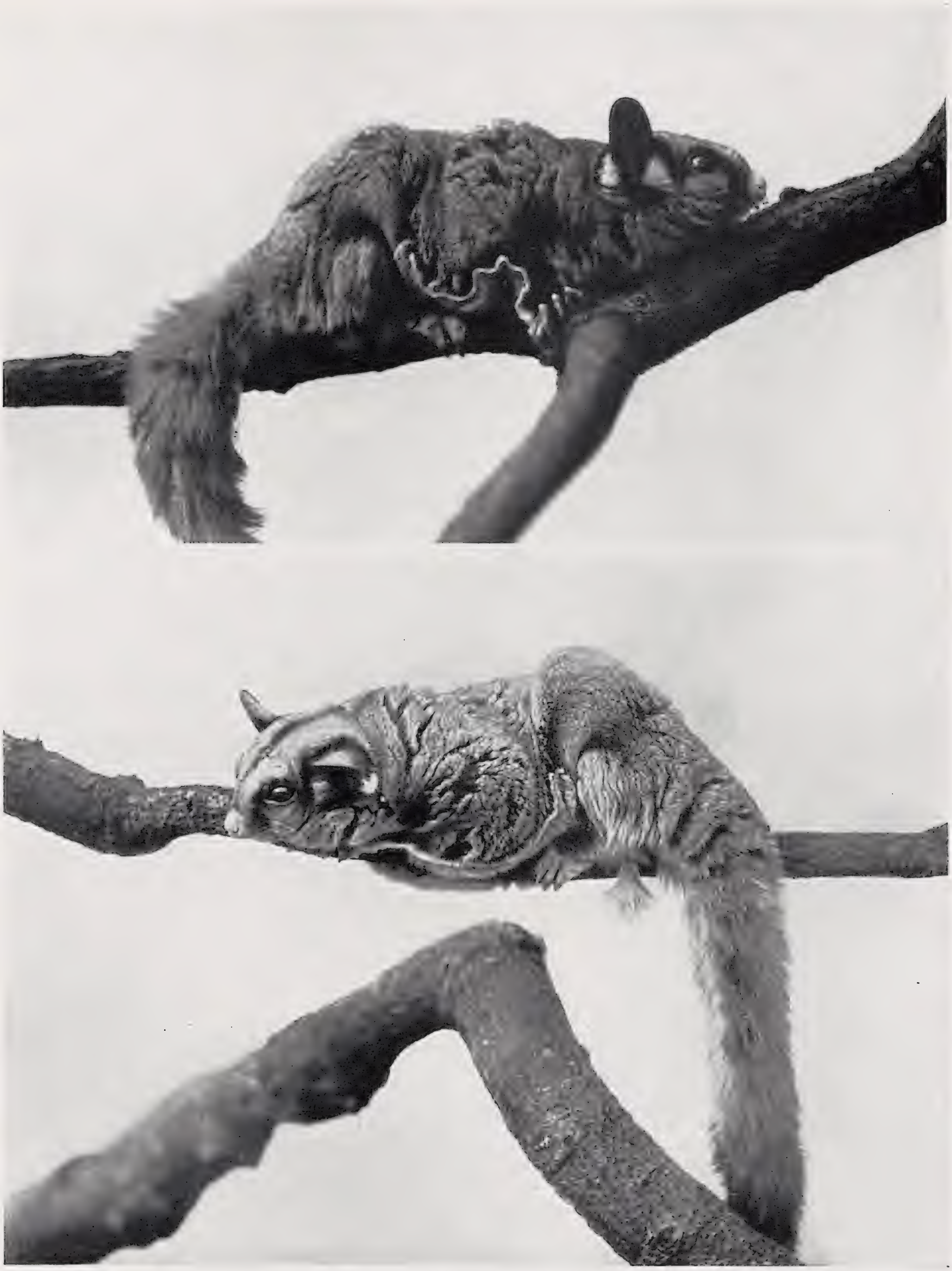




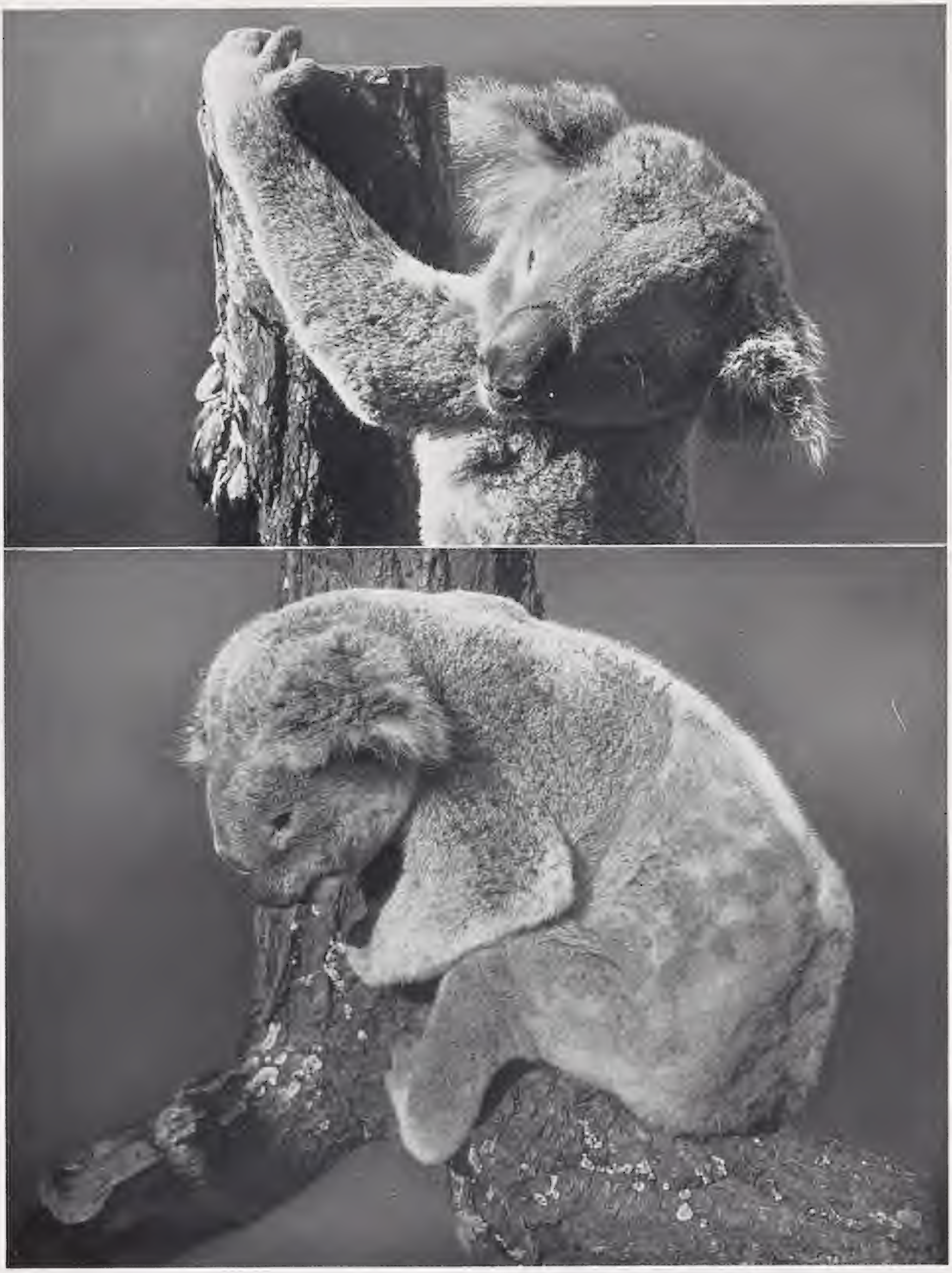
Upper: The fat-tailed marsupial mice are active, tiny animals, with soft gray pelage and round prominent ears. They are terrestrial, do not burrow and live on insect food. They have a well-developed pouch in which they carry the three to four young. This species is found generally over Australia, except in the north. *Lower*: The Tasmanian devil is appropriately named. Its disposition suitably deserves the appellation. It is utterably untamable and this trait is the more remarkable by comparison with the gentle disposition of most other marsupials. The "devil" is entirely black, except for a white band or two. It is more dreaded by dogs in combat than the thylacine. It produces four to five young at birth.



The phalangers are arboreal and by Australians they are called oppossums. They are nocturnal in habit, coming out at night to feed on gum leaves and the wild fruits of the forest. The tail is prehensile, and their modes of progression through the tree-tops combine the awkward groping of the koala, the swinging movements of the 'possums, and the parachute-like flight of the flying squirrels. Their delicate gray fur makes them a prize for the pelt hunter.



The flying phalangers are as graceful and attractive little animals as the flying squirrels of our own country. In a sense, the name is a misnomer, as they do not actually fly. In nature these creatures can only descend in the air. When they wish to ascend a tree, they run up the trunk, the apposable thumb on the hind feet giving them a good grip on the branches. On the ground they are as awkward as a bat. When they wish to cover an intervening distance, they spread the loose skin of the abdomen, which is dark above and white or yellow underneath, and sail gracefully through the air. It is a marsupial and when the young one leaves the pouch it is carried on the parent's back.



Arboreal animals are usually light, lithe and active, but the koala is the antithesis of this; it may be wondered, indeed, how such a heavy and clumsy animal can get a living among the swaying boughs of the giant eucalyptus, but its powerful limbs, armed with short, sharp claws, enable the koala to secure so firm a hold on the smooth bark that it is dislodged with difficulty.

opossums, which are also commonly called phalangers. The Vulpine Phalanger is one of the largest. Its coat is of yellowish hue and woolly texture.

The rarest of all Australian marsupials in American collections is the Koala or "Native Bear," *Phascolarctus cinereus.* This unique creature, like a miniature silvery-hued bear, with its big furry ears and most gentle ways, feeds largely upon eucalyptus leaves, and except upon the extreme west coast of the United States this diet is hard to match. Of all animals, from any country, it is one of the drollest and most attractive. It stands as a star in a country where most of the animals are unusual.

Even in its palaeontological features, the marsupials appear to dominate in Australia. Larger forms preceded the existing animals. Among the fossil types was one approaching the size of a rhinoceros, but of form to indicate that it was dull and inoffensive. There was at least one carnivorous giant, larger than a bear, as well as kangaroos standing twelve feet high. All of this may seem strange and different from the findings in other lands, but the modern fauna of Australia is quite in keeping.

KOALA: NATIVE BEAR

Australia's Most Popular Mammal

Charles Barrett, C.M.Z.S.

KOALA and kookaburra, one a mammal, the other a bird, are the most popular of all Australian animals. The kangaroo is regarded as a national figure, and is represented in the coat of arms of the commonwealth supported by the emu; but neither of these famous natives has won the affection that is enjoyed by our Koala, native bear, and *Dacelo,* the Great Brown Kingfisher, kookaburra.

Phascolarctus cinereus charms everybody but the flint-hearted pelt-hunter, who has taken heavy toll of the species, and almost exterminated it in parts of its range, which extends from Northern Queensland to Victoria. But the koala is strictly protected now in two of the three states he inhabits, and, at least in Victoria, is making up the leeway of many years of persecution. We have a great National Park, Wilson's Promontory, where I have seen nearly fifty koalas during a long day's ramble.

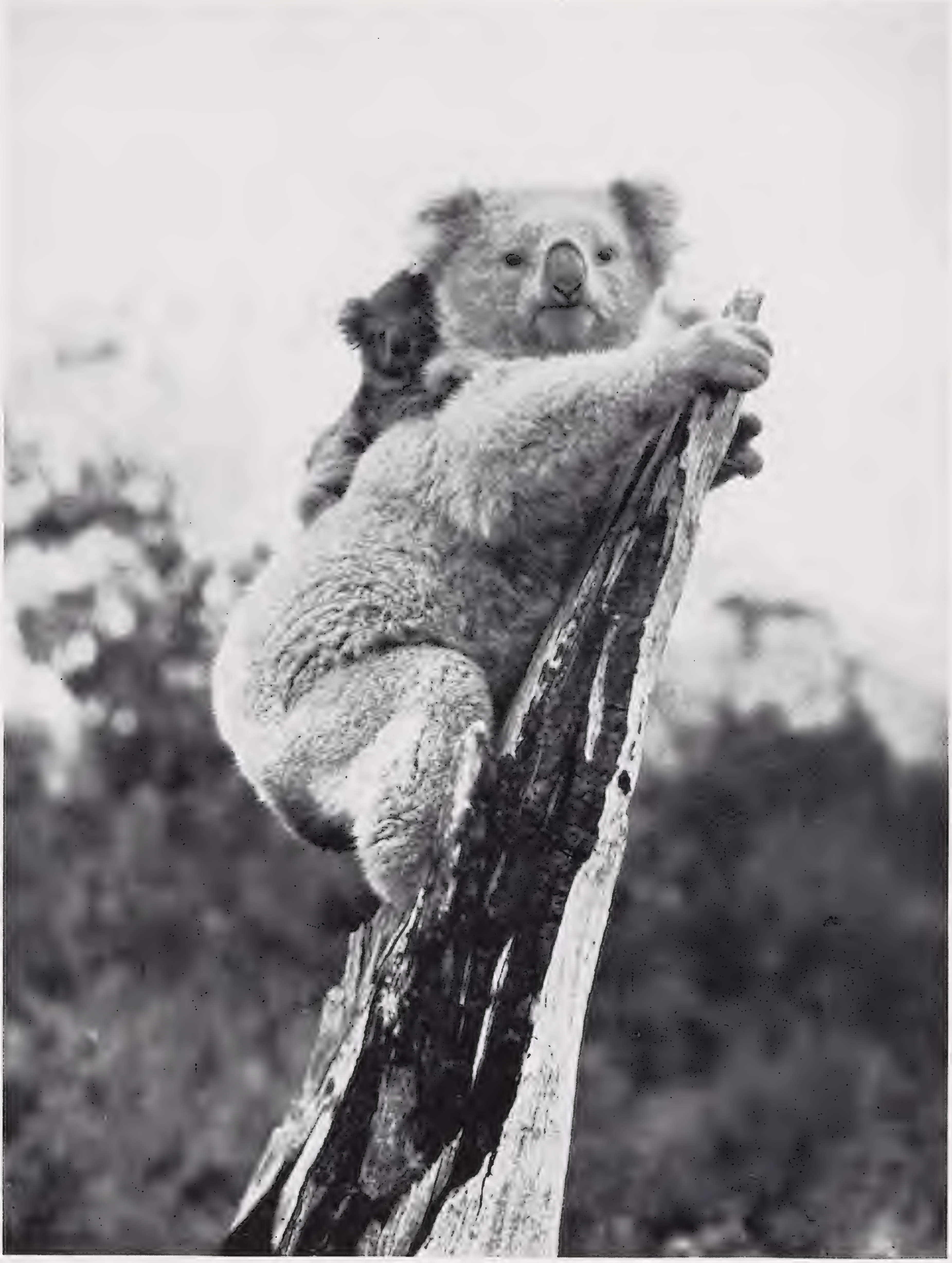
Where to begin a biography of the koala, is a problem. Gleaning from field notebooks, I could give you a mosaic of observations, or a formal account of *Phascolarctus* viewed, coldly, through scientific eyes. Taking the privilege of a nature lover, I present this odd little, grey-furred creature as a personality.

At the Melbourne Zoological Gardens, the koalas' tree, a widespreading old gum, is circled by a high wire-netting fence. Our native bears may remain for weeks without inclination to wander, then the desire for a tree-change rules them. Lack of food—eucalyptus leaves—is a frequent cause of koala migrations, which may be a no greater change than from one tree to another. I recall an exodus, however, which took hundreds of koalas from a sheltered hollow thick with trees, to fresh forests by the open sea. The trees in the old haunt were dying, entirely denuded of foliage by the bears. The pioneers of this koala family had long lived in clover, until their numbers had increased so greatly that the trees in which they lived failed to produce foliage beyond the requirements of this great army of hungry lodgers.

Phillip Island, a favorite resort of holiday-makers within easy reach of Victoria's capital, is also a sanctuary for native bears. There, in the roadside trees, koalas are quite at their ease. They peer down at motor cars whirring by; calmly returning the gaze of nature lovers and the merely curious trippers, and show not the least sign of fear. They know that they are protected; though occasionally one is secretly caught and smuggled away from the Island.

Fear, these toy-like marsupial dwellers of the giant trees, unluckily for its species in the past, either lacks that emotion or expresses it only when hard-pressed. Should you disturb a bear perched in the fork of a tree or clinging to the bole or a bough, it will gaze at you inquiringly, merely indicating a very mild surprise.

The ordinary call of the koala is quite loud and discordant, and literally grates on the ears. It is truly a grating noise, very much like that produced by a saw cutting through a thin slab of wood. These sounds, as they resound at night in the bush, have startled nervous folks unfamiliar with wild life. They gave rise



An albinistic phase of the koala, with her young "Joey" on her back. "Joey" is the Australian common nomenclature for the young of this quaint marsupial. Photograph by Charles Barrett.

once, in a Victorian district, to a bunyip scare! The bunyip is Australia's mythical creature, living in aboriginal legend and camp-fire yarns of the white man. It has been variously described, as a fearsome monster, inhabiting dark, mysterious swamps; and roaring or bellowing a menace to man. Nobody ever has seen the bunyip, but everyone in Australia has heard of it, and some credulous white folks more than half believe that it exists.

Our flying phalanger (*Petauroides*), squirrel it is usually termed—has also a very loud voice, and its cries may frighten "new chums" camping-out in the wilds. Voices of the night are music to the naturalist—unless he be weary and trying to woo sleep, when he may think hardly even of a "bear."

My photographs, taken mostly in the wilds, show the koala in characteristic poses; they form a gallery, unique in its way, for I have hunted *Phascolarctus* with the camera for years, and from the tropics to bleak southern shores. I have climbed tall trees to interview them, and been clawed till the blood flowed, by young ones captured for closer inspection. Koala, although mild-mannered by nature, can fight, or rather, struggle for freedom. It has sharp claws with power behind them, and uses them gamely enough. Its limbs are strong; indeed the whole animal is very bulkily made for an arboreal species. It looks clumsy when progressing along the ground, but up aloft, the koala is seen at its best. Its face is truly, its fortune. No other mammal in the world, surely, has a more appealing, childlike expression than that of a koala in repose, and this popular favorite of ours is as inoffensive as it looks. It does no harm, excepting to gum trees, the kinds whose leaves are richest in oil. It is from these Eucalyptus that oil is distilled in vast quantities for various uses. Eucalyptus oil on loaf sugar is taken as a cure for colds and coughs, yet the bears, who feed most exclusively on gum-leaves, have voices as hoarse as you please!

Fur-hunters are responsible for the decline of *Phascolarctus,* in many of its haunts and disappearance from others; but disease, also, has been its enemy. During three years, 1887 to 1889, the mortality from opthalmia and a disease of the skull was terrible. Another visitation spread over the period 1900 to 1903. Millions of koalas were victims of the scourge, and this may occur again if the species should ever increase to multitudes, since we cannot guard them from disease. In the south no open season for koalas is allowed, but should the fur-hunter, given a month or two of free killing, it might place the koala with the dodo. Our protected bears are prospering now; disease is claiming only a few, the normal percentage probably.

Excepting in the season that makes all creatures sociable, the koala is solitary. Of course, there are communities of sorts. A tree may be the home of several koalas; and all the trees of a group be tenanted. Still, communal life is lacking.

Parent and young are frequently seen, and present a charming picture. In mid-winter—June is the usual month I believe—the baby koala is born. Large, even moderate-sized families are rare among koalas. One cub is the rule, and twins would be a novelty. For about three months the little marsupial lives cosily in its mother's pouch. Then it is ready for the open air. The change is not much of a venture, since the cub merely climbs to its parent's broad back, a safe perch for another quarter of the year. When six or seven months old, the woolly youngster—"Joey" is a bush term for it—literally ceases to be a burden on its mother. It is now able to fend for itself, and chooses, perhaps after wandering for a while, a comfortable low fork in a gum tree as sleeping quarters in the daytime. The koala is mainly nocturnal in habits and usually is found asleep between dawn and sunset. It feeds at night among the topmost branches, having a nice taste for gum-tips. When the supply of tender shoots fails, koala shifts his quarters to a neighboring tree if there be one available not already eaten out. He may have to travel a bit, or go shares with other bears not at all anxious for his company.

Climbing is as natural to the native bear as swimming is to a duck; only the marsupial going aloft cuts rather a sorry figure compared with the cruising water-bird. Koala digging his claws into the bark, makes a kind of jump, rests, and jumps again. The ascent is jerky and ungraceful, but not so slow as you might imagine it to be. Though I'm an experienced climber, I've often been beaten easily by a bear. I tried once to head off a mother and

A naturalist's camp in the heart of tropic Queensland. The lovely Cycad, *Borvenia*, grow here in great abundance.
Photograph by Charles Barrett.

Breaking camp. Loading a pack-horse in the Queensland forest country.
Photograph by Charles Barrett.

babe to get them within range of a stand-camera. The mother with "Joey" clinging tightly to the dense, woolly fur of her back, jumped to the ground, lumbered through bracken for twenty yards or more and climbed a tall tree-stump very quickly. I snapped the pair easily then—securing the first photograph of the kind—an albino koala with a cub of the normal grey-brown hue.

This was at Red Hill, on Wilson's Promontory (our park of 101,000 acres, all reserved for wild life). Gum trees grow under the Hill in the swampy land where snakes are to be seen, and in spring where the dainty white butterfly-iris blossoms. I rode among the eucalypts, counting teddy bears. They were there in dozens; solitary, several in a tree, and mothers each carrying a cub on her back. The month was October. When I passed directly beneath their perches, the koalas dozed on or looked down in their droll, inquiring manner. Drumming with a stick on the tree-trunk woke the sleepiest fellows; two or three of them grunted, and moved to higher forks; mostly they declined to move, excepting their heads, to gaze at the noisy intruder.

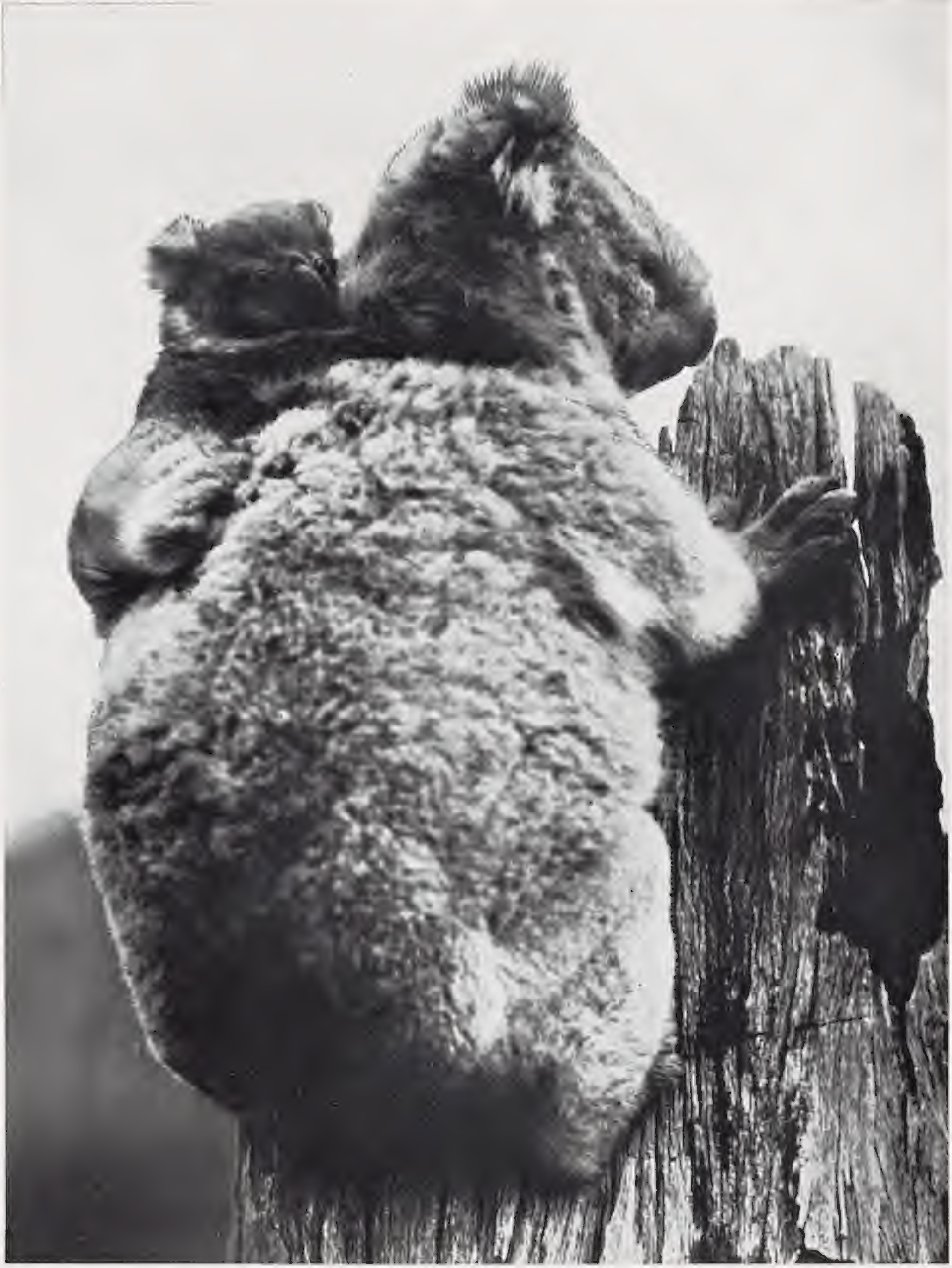
As a pet, the koala indulges its instinct for climbing by getting on to human shoulders when given a chance to do so. It grips firmly, and a stranger unused to its ways may be scratched severely if he ventures to handle a tame teddy bear. A young farmer friend of mine in Queensland has a whole family of koalas as pets. They are gentle as dormice with their owner, nestle in his arms, squat upon his shoulders and plainly enjoy his company.

The koala's face has an almost human appearance, so pensive and droll as to lend itself readily to caricature. In our newspaper cartoons, in comic supplements and in fairy stories the quaintest little mammal in the world figures to the delight of grown-ups and children.

The koala when wounded clings to his tree so tenaciously, oft-times, that even in dying the hold is not relaxed, and the victim's body may not fall until some time after death. Though arboreal and devoted to a diet of leaf shoots

The haunt of the koala in a gum forest in Victoria's National Park, Wilson's Promontory. Some of the trees are nearly denuded of their leaves by the multitude of koalas which are here protected by the Commonwealth. Photograph by Charles Barrett.

A koala climbing a gum-tree. Only the smooth-barked species with high oil content are selected by the bear for his food, and only a few species form suitable food-trees. Photograph by Charles Barrett.



The koala has one young at birth, which is born about June. It is carried in the pouch for three months and spends the rest of the year on its parent's back, when it is then ready to shift for itself. Photograph by Charles Barrett.

on the lofty boughs, the koala at times goes for a terrestrial ramble, progressing clumsily on all fours. These excursions as a rule are made in quest of food.

Color variation in the koala is not considerable beyond the range from light to dark grey, which is the general hue of the thick fur. Mottled specimens occur, however, and of albinism in the koala I have several records. Unfortunately these attractive little animals suffer much from parasites, hideous ticks, which often increase until they sap the life from their host. I have found, lying on the ground in the forest, the bodies of bears killed by ticks. Intestinal parasites, also, afflict the koala. All things considered, despite his indolent life, *Phascolarctus,* is in no better case than many other creatures of the wilds. Under protection he is thriving and dimly may be aware that we acknowledge his right to a place in the sun.

Koala really does resemble, superficially, a small bear. He has no tail, his ears are broad and furry, and his head and the stout limbs are bear-like. Native bear he is termed almost universally, in Australia. The title "Native sloth," mentioned by Lydekker, in his volume on "Marsupials," I have never heard applied to *Phascolarctus,* whose sluggish habits certainly might have suggested it to an uncritical observer.

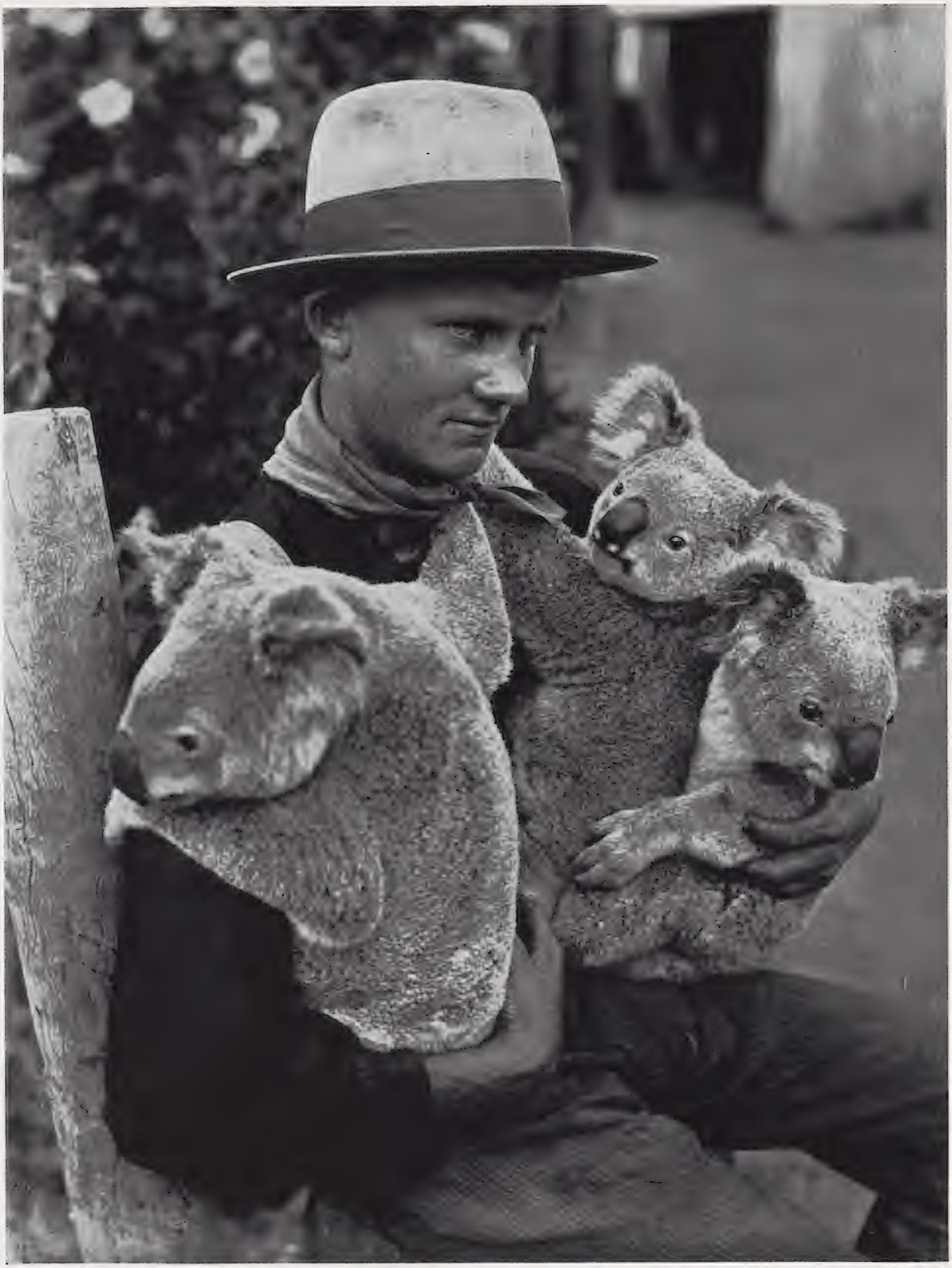
Browsing through old books, travellers' tales and records of the early days when our cities were towns or villages, and aborigines still hunted on the outskirts of settlements, I have gathered some marsupial lore. Here is a sample, Colonel Patterson's account of the hunting of koalas by the blacks in the vicinity of Port Jackson:

"The natives examine, with wonderful rapidity and minuteness, the branches of the loftiest gum-trees, and upon discovering a koala they climb the tree in which it is seen, with as much ease and expedition as a European would mount a tolerably high ladder. Having reached the branches, which are sometimes forty or fifty feet from the ground, they follow the animal to the extremity of a bough, and either kill it with the tomahawk or take it alive. The koala feeds upon the tender shoots of the blue gum-tree, being more particularly fond of this than of any other food; it rests during the day in the tops of these trees, feeding at ease, or sleeping. In the night it descends and prowls about, scratching up the ground in search of some particular roots."

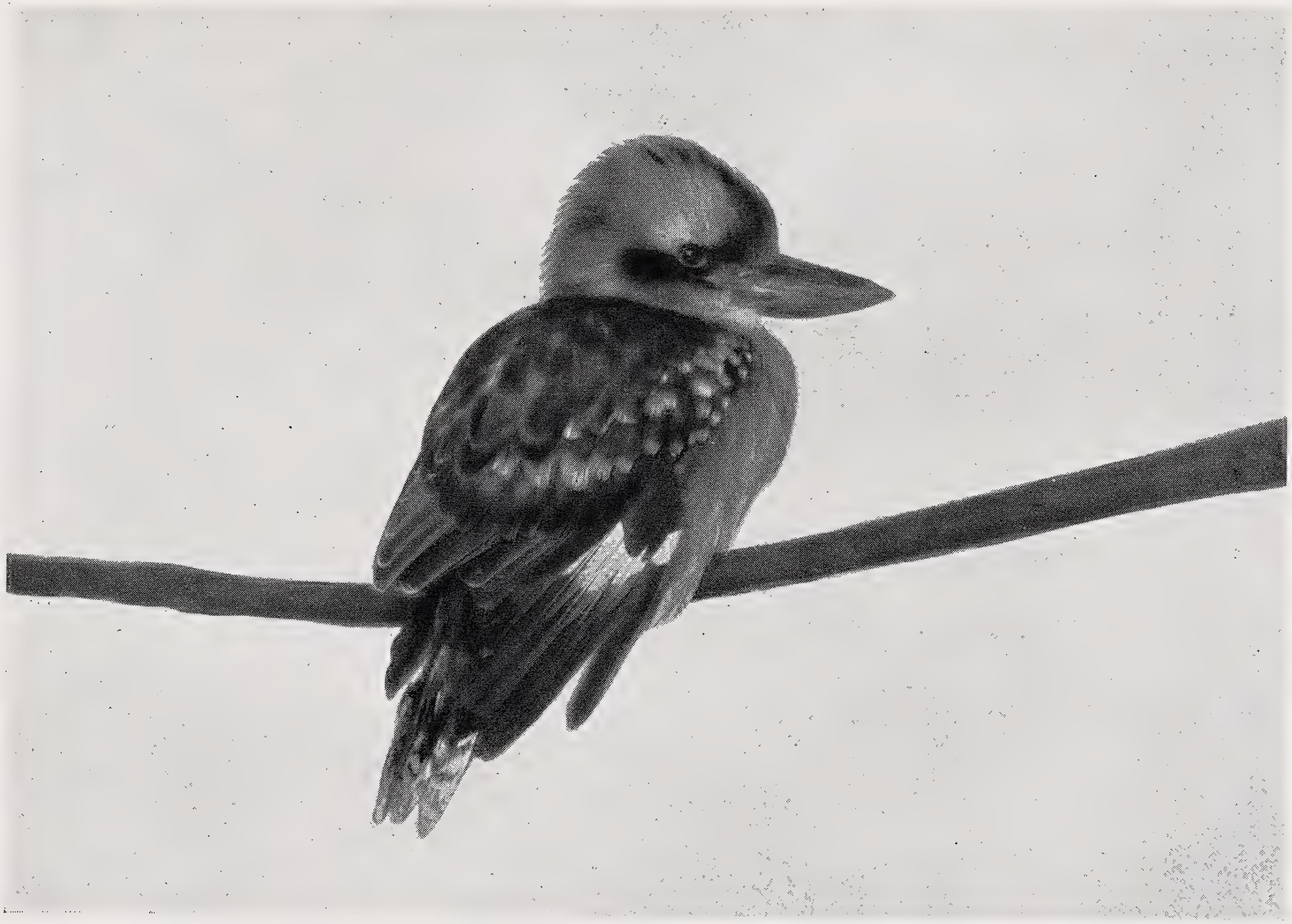
An old Bushman of the sixties gives an entertaining account of the koala, describing it—a pretty good portrait—as "about the size of a large poodle dog, of a light grey color, with white throat and rump and no tail; and a very comical-looking fellow he is, with his round, bald face, small black eyes, and square fringed ears." This early observer, who shot kangaroos and other animals and birds for the markets in Melbourne town, had scruples about shooting at the bears with shot, owing to the cruelty involved. The koala's hide is thick, and a bullet only will be fatal when the animal is at any height—unless the victim is riddled with shot: a miserable kind of sport!

The aborigines regarded the flesh of the koala as a delicacy—good eating, as we say. I've never tried it, nor am I likely to do so! It is said to be eatable, at a pinch, the flavor being not unlike that of a true bear—the species not named by my authority, the author of an Old Time book of wanderings in the Australian wilds.

Millions of koalas have been killed for the sake of their pelts; millions of opossums (phalangers), of kangaroos, and other marsupials. The trade, so hateful to lovers of wild life continues, but not unrestricted now. We are protecting species in danger of extinction, and giving more thought to conservation generally. The notable work done in the United States is known and highly appreciated in this Commonwealth of ours. The saving of the koala in Victoria, shows what may be done when the State guards its wild life with the approval of its people—all but those who profit by freedom to kill the fur-bearer. The wild dog of Australia *Canis dingo,* often met with in koala country, still flourishes, though it has for nearly a century been warred against, and wherever it ranges has a price upon its head. He is a sheep-killer and preys also upon wallabies, ground-birds, and other creatures. This is a pest animal, native but not marsupial, that has but few friends excepting among the aborigines, who alone are able to domesticate him. Grown up, it is treacherous, sneaking, and practically untameable, but as a pup, it has some charm—as my photograph proves.



A young Queensland settler and his family of pet koalas. The koala is both guileless and gentle and when disturbed it gazes down from its perch without exhibiting fear. The voice of the koala is distinctive, a hoarse, grating call, and vies with the phalanger as being the loudest sound made by a native animal. Photograph by Charles Barrett.



The Kookaburra.
More than half of the kingfishers known to science occur nowhere out of the Australian region, and among its wonders are kingfishers that do not care for water and never eat fish except in captivity. This interesting bird does not frequent water courses and feeds on reptilian forms and other dry land fauna.

KOOKABURRA

The Giant Kingfisher of Australia

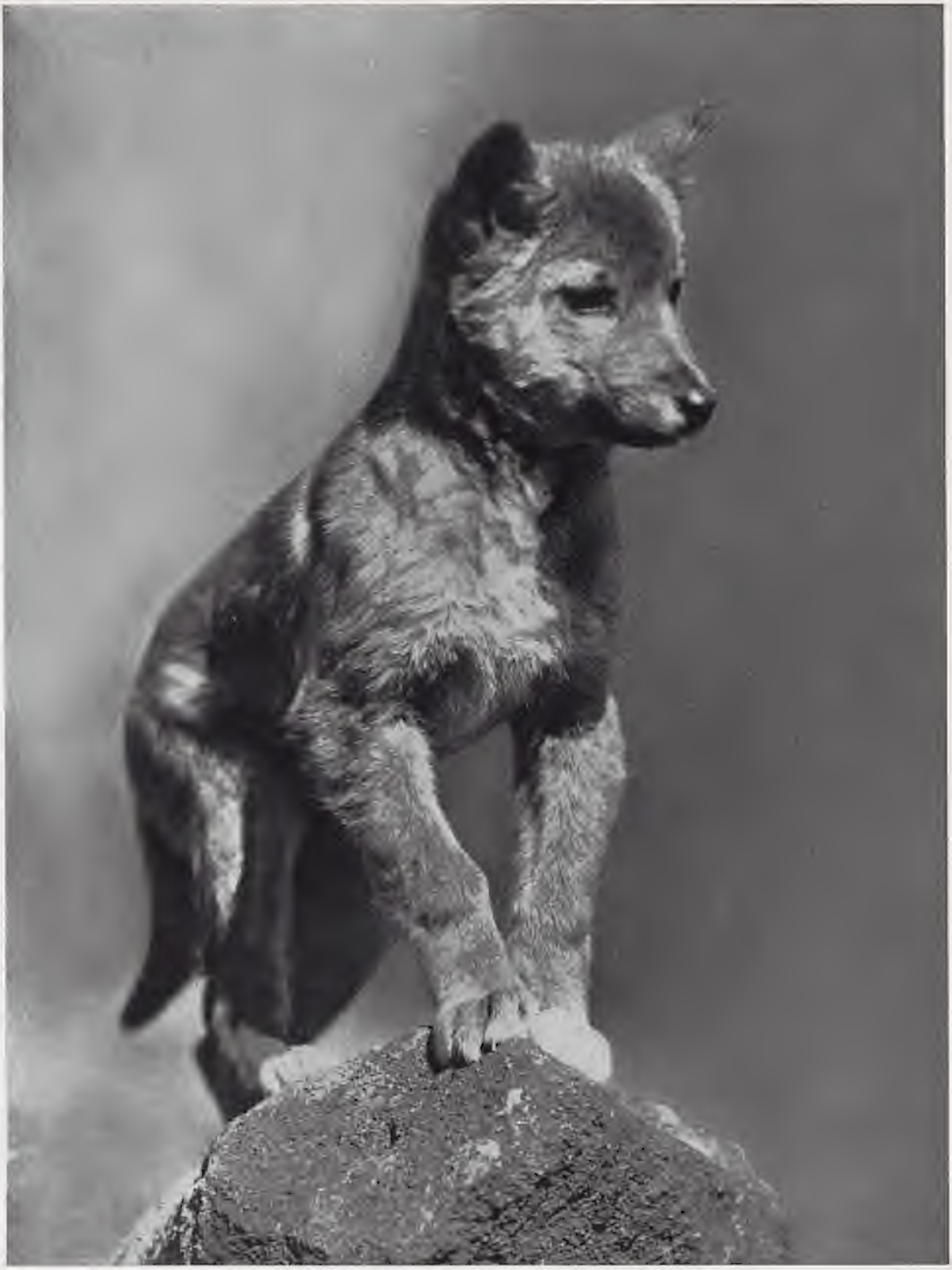
LEE S. CRANDALL

IN Eastern Australia, probably no bird is better known or better liked than the giant kingfisher or laughing jackass, familiarly known as the kookaburra. Various subspecies are found, ranging from Cape York in the north to Victoria and South Australia. In the vicinity of Sydney, New South Wales, it is particularly abundant, and is often seen perched on telegraph wires, or on dead stumps in clearings. For unlike the kingfishers of America, the laughing jackass is a bird of field and open forest, rather than of lake and river. Its food consists largely of insects and mice, with any unfortunate small birds or mammals it may be able to capture.

This habit of bird catching is a trait which has made the kookaburra less popular than it might be with some nature lovers. In fact, it is not above raiding the barn-yard for young chicks, when other food is scarce. But its friendly, familiar habits more than make up for its delinquencies.

The name "laughing jackass" is derived from the bird's loud, rattling call-note, which might easily be taken for wild, demoniac laughter. This is heard most frequently just as darkness is falling and again just before dawn, while it is still quite dark. So regular is the bird that it is known, in the back stations, as the "bushman's clock." At certain seasons, the birds roost together in small flocks. Then, when they call in chorus, the noise is deafening and can be heard for considerable distances, in the stillness of dusk or dawn.

Once commonly imported by American dealers, restrictive laws in Australia have made the laughing jackass extremely rare outside its own domain. Fortunately, however, it is a hardy and vigorous bird, adapting itself readily to the conditions of confinement, and usually living out a long span of years. Consequently, there is usually at least one specimen to be seen in the Large Bird House of the Zoological Park.



In Australasia there are two species of wild dogs, the dingo or warrigal of Australia and the native dog of New Guinea. The dingo is the most widely spread of the few native animals that are not marsupial. It is found all over the continent, but not on the Island of Tasmania. Zoologists have not been able to account absolutely for the presence of a wild dog, a typical representative of the fauna of the outside world, in Australia. It is supposed that it came to Australia with the Aborigines "at some period in that vague borderland of time where the geologically recent meets the historically remote." An Australian scientist has stated that the dingo is nearer the ancestral type than to the other races of dogs. Photograph by Charles Barrett.

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May-June, 1931

BULLETIN
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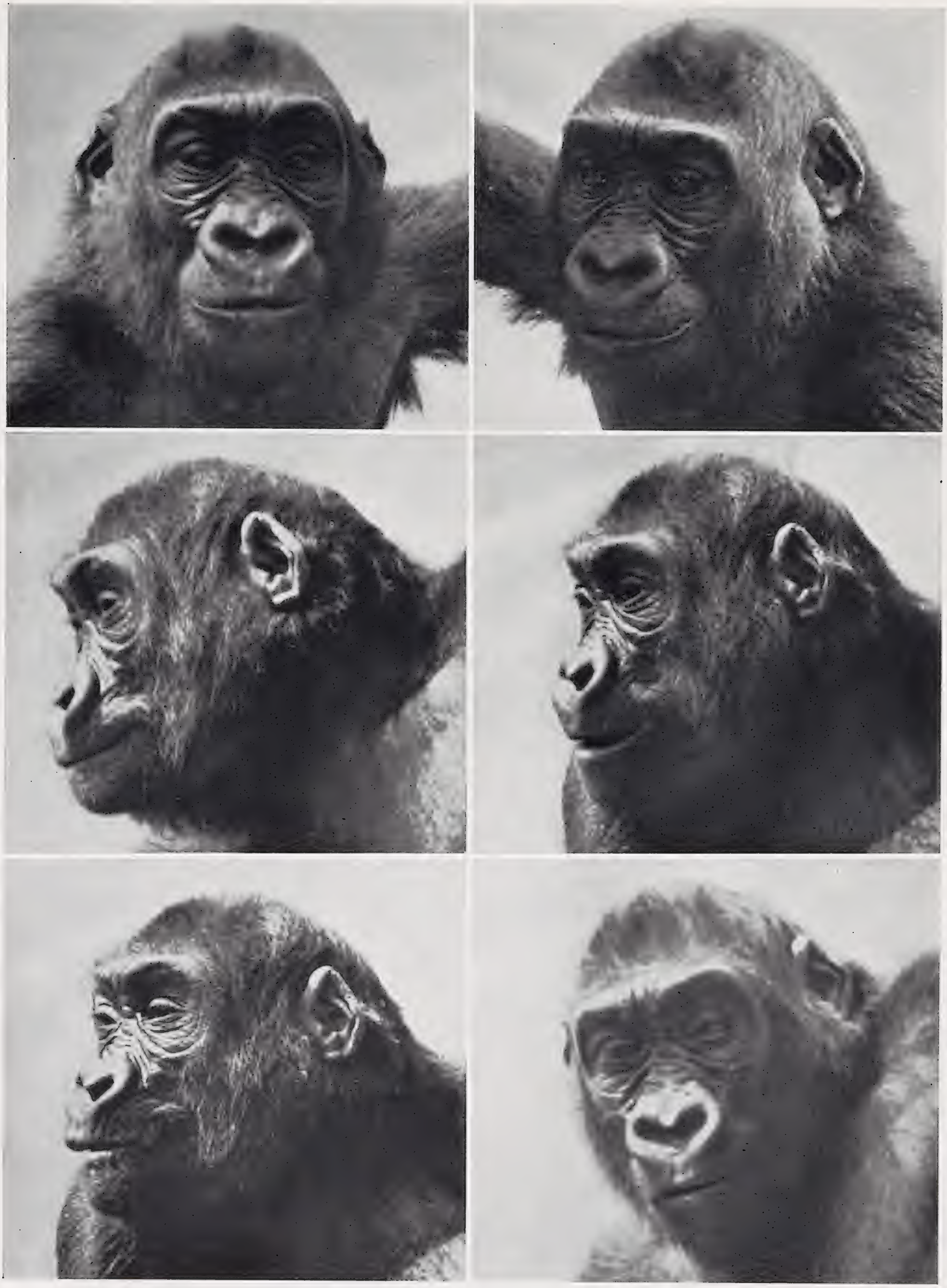

Several recent portraits of the Society's gorilla.

BULLETIN
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The Zoological Park's Young Female Gorilla, Janet Penserosa

With notes concerning her companion a young female chimpanzee, Ellen Allegra

CHARLES V. NOBACK
New York Zoological Park

Illustrations, from figures five to twenty-eight, represent a record of development from the day the gorilla arrived until the present time. Figures 5, 6, 7, and 8 were made by the International News Photo Service, and those following by E. R. Osterndorff. The illustrations, other than those mentioned, taken by Elwin R. Sanborn in 1931, show the gorilla's excellent condition at this time. All photographs were made in the Zoological Park.

ALTHOUGH vague descriptions of large and shaggy, man-like apes, living in the heart of Africa and called gorillas, are found in earlier literature, it may be recalled that the gorilla (*Gorilla gorilla*) was virtually an unknown animal one hundred years ago. The gorilla as known today was definitely identified for the first time by Savage and Wyman in 1847, only eighty-five years ago. Yerkes and Yerkes in their outstanding work, "The Great Apes," speak of Savage and Wyman as those "who discovered this animal to the scientific world."

An adult gorilla, which may range from four to six feet in height and weigh approximately four hundred pounds, has never been seen alive outside of its native habitat, which includes part of the Belgian Congo, Gaboon Country and the Cameroons of Central Africa. Relatively few living infant gorillas have been brought from central Africa to any civilized country, as most of them either perished on board ship or died soon after reaching civilization.

It was not until 1855 that the first living infant gorilla was brought from Africa to Europe. The following quotation from "The Great Apes" by Yerkes and Yerkes, contains references to the first infant gorillas that reached Europe:

"In 1855 there was shown in England as a chimpanzee named Jenny, an ape which was subsequently identified as a young gorilla. It is known in the literature as Wombell's gorilla. The first description which we have discovered is that of Waterton (1858) who mistook the animal for a chimpanzee. This specimen, which seemingly was the first living gorilla to reach Europe and to be presented as an exhibit, Waterton tells us, continued with the menagerie until it reached Warrington where 'without any previous symptoms of decay, Jenny fell sick and breathed her last.' Further information about this first gorilla may be found in Sclater (1877), Keith (1896), Scherren (1905), and elsewhere. Confusion of dates appears, in that certain authors refer to the animal as exhibited about 1860.

"The second European specimen, and the first to be exhibited in Germany, apparently is the Falkenstein gorilla which in June, 1876, was purchased from Dr. Falkenstein by the Berlin Aquarium for the sum of twenty thousand marks.

"What appears to have been the first specimen to be exhibited in France is described by Milne Edwards (1884) as a male estimated at about three years of age. Presumably the animal arrived in Paris in 1883. He survived a short time."

In "*News Bulletin* of the Zoological Society," No. 2, published by the New York Zoological

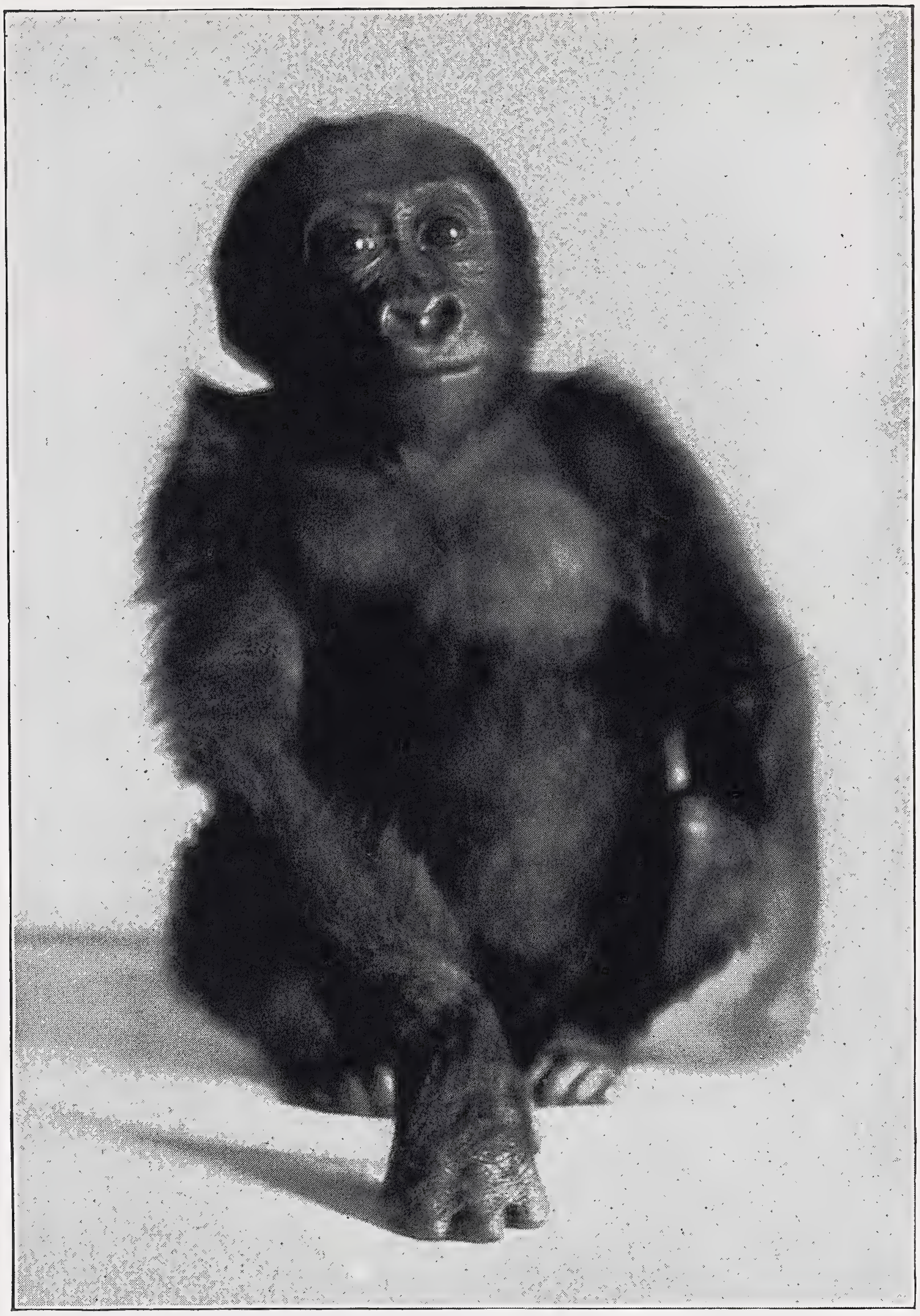

Fig. 1. Photograph of a baby gorilla which probably was the first one of this interesting anthropoid ever brought alive to the United States. The animal arrived in Boston, Massachusetts, May 2, 1897. It lived but a short time, dying five days later. A reference is made to this incident in the text. Photograph from an unknown source.

Society in October, 1897, Dr. W. T. Hornaday records the arrival of what is known as the first living infant gorilla to reach the United States:

"For many months I have watched with great interest the work of two American ape-fanciers, the Edwards Brothers, in training orang-utans and chimpanzees, which they continually exhibit. Ever on the watch for new simian 'talent', they found in Liverpool last April [1897] in the possession of a dealer, a genuine baby gorilla, alive and well. They promptly purchased the strange little creature, and on May 2, the first specimen of *Troglodytes niger* (*Gorilla gorilla*) ever seen alive in this country, arrived in Boston and was exhibited there.

"It was twenty inches in height, fifteen and one-half pounds in weight, and its portrait is reproduced herewith (Fig. 1). The sailors who brought it to Liverpool from the Gaboon country stated that its capture was due to an accident to its mother, who was killed by a falling tree. When first captured the natives fed it on plantains and rice, but on reaching civilization its bill of fare was extended to include milk, dry bread, apples, oranges, figs and bananas.

"Although the little creature was a hearty eater, an energetic fighter, and apparently desirous of long life, fate proved unkind. For such a delicate and sensitive animal, it was brought across the Atlantic a little too early. On the voyage over it contracted a severe cold, which resulted in its death only five days after it reached Boston."

Three infant female gorillas have been received at the New York Zoological Park at different times during the past twenty years. The first one was received on September 23, 1911, and died twelve days later. The second, Dinah, lived at the Park for over eleven months, from August 24, 1914, to August 1, 1915. The third infant gorilla received at the New York Zoological Park is Janet Penserosa, the subject of this article.

Early in the summer of 1928, Rev. W. Reginald Wheeler left the Gaboon country in West Central Africa for the United States by way of France, bringing with him three baby gorillas and a baby chimpanzee when he sailed from Duala, a West-Central African seaport. The anthropoid apes were quite ill during the voyage to France, and two of the gorillas died on board ship and were buried at sea.

Although the surviving baby gorilla and chimpanzee were ill during the remainder of the journey, they managed to live on a diet of milk, bananas and bread. Upon reaching France they were taken to Paris and boarded at the Jardin des Plantes, where they were nursed and treated until arrangements could be made to transport them to New York. They left France for New York in October 1928, sailing from Cherbourg on board the White Star S.S. *Olympic,* housed in the ship's animal quarters.

The midnight of October 30, 1928, was calm as the *Olympic* quietly docked at Pier 59, North River, with a sick baby gorilla and chimpanzee as part of her living freight.

Mr. William White Niles, Secretary of the New York Zoological Society, arrived at the pier the following morning to accept the rare gorilla for the Society from Rev. W. Reginald Wheeler. Acting under instructions from Dr. W. Reid Blair, Director of the New York Zoological Park, the writer proceeded to Pier 59 early in the morning of October 31, to make a preliminary examination of the anthropoid apes. Mr. Niles and the writer went on board ship where they saw the weak, emaciated gorilla and chimpanzee huddled close together in one of the comfortable cages of the ship's animal quarters. Fortunately such excellent accommodations had been provided for them as otherwise they might not have survived the ordeal of so long a journey.

The dock was a beehive of activity as the huge ship's cranes unloaded baggage while passengers left the ship to greet their friends on shore. Those who passed the customs examination left immediately and were soon lost in the maelstrom of the big city, unmindful of the fact that a baby gorilla and chimpanzee were soon to be on their way to the New York Zoological Park. After an inspection, at about eleven o'clock, the customs officials permitted the gorilla and chimpanzee to leave the dock. Each one was carefully wrapped in a warm woolen blanket and carried to a waiting automobile where a motion picture was made by Rev. Mr. Wheeler. They were soon on their way, through crowded city streets, bound for the Hospital at the New York Zoological Park.

They reached their destination at one o'clock in the afternoon, and upon arrival at the Hospital were placed in a sanitary cage, which had been provided with clean, fresh straw. Here they were allowed to remain alone in order that they might relax and recover from the fatigue of their long and strenuous journey.

They appeared to be somewhat bewildered when first placed in their warm, comfortable quarters within the quiet atmosphere of the Hospital. Their curiosity was soon aroused, however, as they gazed about to inspect their new home. The cage in which they were temporarily housed was virtually a four-foot cubic room whose ceiling and front consisted of a wire network.

They played with the straw or moved about cautiously. Both would immediately huddle close together like two lost children and hold on to each other at the sound of strange voices or footsteps in the hall. The chimpanzee literally "mothered" the baby gorilla. It was with great difficulty that they could be separated as they would most strenuously resist.

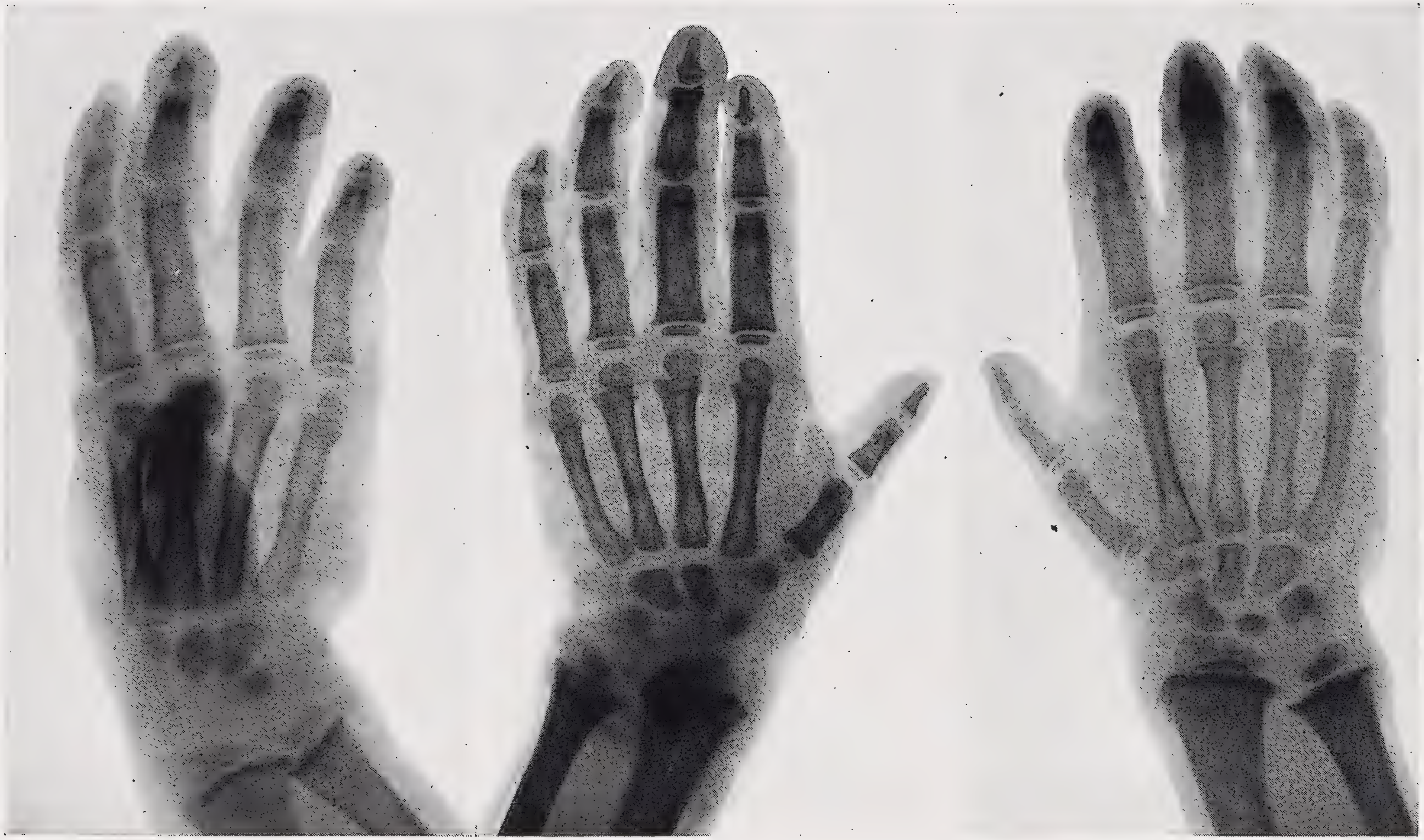

Fig. 2. Radiographic record made on November 3, 1928, showing the bones of Penserosa's hand. Four of the wrist bones (carpals) stand out quite clearly. A fifth is very faintly revealed in the negative. Fig. 3. A few months later, March 10, 1930, five wrist bones appear in the radiograph. Fig. 4. A year later, when the age of the gorilla was estimated to be three years, a full set of wrist bones (carpals) were found by radiographic examination. Nine carpal bones were present, where usually there are but eight; the extra one being the centrale. Her four permanent molars (comparable to the six molars in man) also had erupted at this time. These observations, together with her rapid increase in weight (as may be seen in the table which is printed elsewhere in this article, indicate that physical development in the gorilla is quite rapid. A full set of carpal bones is not present in man until about the ninth year.

At two o'clock they received a few pieces of orange pulp and a banana, which they ate very slowly. Later, at about four o'clock in the afternoon, a cup of milk with an egg beaten in was offered to them. The chimpanzee readily drank her cup of milk with egg but the baby gorilla was very slow and persisted in her refusal to eat. It took more than half an hour to coax her to take her share of milk and egg.

About six o'clock after finishing their evening meal, they moved about in their new quarters until sunset. At seven o'clock in the evening the last person left the building, leaving the infant gorilla and chimpanzee by themselves without the benefit of a night nurse or attendant. Upon observation it was noted that they gave no audible indication of fear when left in total darkness. After their journey and the excitement of travel they were apparently very tired as both were soon fast asleep. While on his tour of inspection, the night watchman observed them every two hours during the night. His report the next morning stated that they were found to have been quiet and fast asleep during the night. The watchman did not turn on any of the electric lights in the hospital building but used a small flashlight instead.

Early the next morning they were wide awake and played about the cage together, the chimpanzee pushing the baby gorilla around so that at times the gorilla would cry, and then the chimpanzee would mother her again.

The infant female gorilla weighed seventeen and one-half pounds (7.84 kg.) while the baby chimpanzee weighed eighteen pounds (8.18 kg.). They were estimated as being about eighteen to twenty months of age since each had a full set of milk teeth, although the canine teeth of the gorilla were not fully developed.

After an examination was made it was found that both of them were greatly emaciated and weakened from malnutrition and a cold. They were also afflicted with a skin disease (dermatitis). Because of their illness and poor condition it was not believed that they would survive very long, consequently they remained at the Hospital for care and treatment. Since they were emaciated and ill, the veterinarian's immediate problem was to keep them alive and then to do everything possible to restore them to a state of sound health.

The general plan of procedure was, first, to allow them to rest and relax in their quiet hospital quarters; second, to prescribe an adequate, nutritious diet, and third, to render indicated medical care and treatment.

Rest and Relaxation

A roomy cage twelve by fourteen by nine feet, enclosed with one-inch electric weld wire mesh, was built in one of the larger Hospital rooms. This was provided with a wooden floor, a bench, a pole one and one-half inches in diameter, and a trapeze. Straw covered the floor of the cage and a large skylight admitted a flood of sunlight. Their smaller cage served as a sleeping compartment while the larger one was used as a playroom for recreation and relaxation.

Diet and Method of Feeding

The next consideration in the care of the baby gorilla and chimpanzee was the choice of a suitable variety of foods to supply the necessary elements for growth and development. The food requirements of an infant gorilla are quite similar to those of the human infant so far as physical growth is concerned. Milk, eggs, fruits and vegetables, with a small amount of bone meal and cod liver oil were selected to form the basis of her diet.

With the object of providing a wholesome, nutritious, palatable and adequate diet for the baby gorilla the following feeding schedule was prescribed and followed out from the first day of her arrival to the present date. The only important change in the diet was that as she grew and increased in weight the quantities of food were materially increased.

Feeding Schedule:—Breakfast at eight o'clock consists of milk and eggs prepared as follows: Two tablespoonfuls of whole dried milk and three eggs are added to a quart of diluted condensed milk. This combination is then thoroughly mixed with an egg beater. She is permitted to take as much of this food as she desires. During the first few months at the Hospital a prepared baby food was also added but later discontinued. Two to four teaspoonfuls of Norwegian cod liver oil with some bone and blood meal are given at nine o'clock.

The principal meal of the day is fed at 12:30 to 1:00 P.M., and consists wholly of fruits and vegetables. Bananas form a substantial part of this meal. The young gorilla may eat from two to six each day. It is interesting to note that the gorilla as well as the chimpanzee are very fond of eating the inner white lining (endocarp) of the banana peel. They will frequently eat the whole banana skin. While human beings usually prefer to eat fully ripe bananas which taste relatively sweet, the gorilla and chimpanzee prefer those which are not quite fully ripe, that is, bananas with a tinge of green in the yellow skin and which to the average human taste are somewhat bitter—the taste of bananas not quite ripe. The ripe bananas naturally contain more sugar while the others have more starch.

Ripe oranges are fed each day and are relished by them. The chimpanzee prefers the orange pulp but does not care for the rind or skin. The baby gorilla, however, is very fond of eating the endocarp of the orange skin.

Apples are usually fed on alternate days. Various combinations of the following vegetables are fed daily—unpeeled potatoes, boiled or raw; lettuce, carrots, and rice in the form of a simple rice pudding with a good supply of raisins. Like children, they pick the raisins out first. They are permitted to eat as much of the above fruits and vegetables as they desire. Their food, though plain, is wholesome, nutritious and inexpensive.

Some writers state that gorillas live upon and like to eat young shoots of the bamboo plant. Our gorilla, however, refused to eat some canned bamboo shoots which were obtained from a Chinese restaurant. She likes white bread, butter, and Swiss or mild American cheddar cheese if they are offered to her. Sunflower seeds, peanuts and chocolates are also relished. These articles of food have at times been offered to her but they do not form a part of her diet. Later it was observed that the gorilla was very fond of picking grains of wheat from the heads of straws and eating them. She also likes to eat leaves, buds and the tender bark of wild cherry, sweet gum and other trees.

Medical Care

Appropriate medical treatment was prescribed when necessary. As a part of the general plan in the care and treatment of these apes it was decided not to "coddle" or pamper them in any way but to let them become self reliant.

They were irradiated for fifteen minutes each day with ultraviolet light from a mercury vapor lamp at a distance of not less than six feet. The first exposures were from three to five minutes and then the time of exposure was lengthened. The ultraviolet light seemed to improve the hair coat but it cannot be definitely stated what the exact effect of the light was. The use of artificial "sunlight" continued until spring, as will be noted later in this article. During their first winter at the Park they were kept indoors because they were ill.

An X-ray examination of the gorilla's hand was made on November 3, 1928, and indications that she had been suffering from the effects of malnutrition were present. This X-ray record was the first of a series of radiographs which later served to indicate that the bones of the hand in the growing infant female gorilla develop more rapidly than those in the hand of the human child (Figs. 2, 3, 4). Observations on the development of the teeth and semimonthly weight records were made which also tended to support the view that growth is very rapid in the young infant gorilla.

Within ten days after her arrival the infant gorilla gradually became accustomed to her new home (Figs. 5, 6, 7, 8 and 9). Her daily routine began with a breakfast of milk and eggs at eight o'clock, followed by a rest period of half an hour, after which, at nine o'clock, she received her cod liver oil. The remainder of the day was spent in the playroom where she would play with the chimpanzee or else rest and relax.

The midday meal, consisting of oranges, bananas, lettuce, rice and raisins, apples or potatoes, was served at 12:30 to 1:00 P.M.

As the walls of the play cage consisted of an electric weld, one-inch wire mesh, the gorilla and her chimpanzee companion would climb all around the inside of the cage at will, or they would climb up the pole or swing on the trapeze until late in the afternoon. After their evening meal they would be left to themselves until early the next morning. With the chimpanzee lying on her back and the gorilla on her side, they would sleep throughout the night.

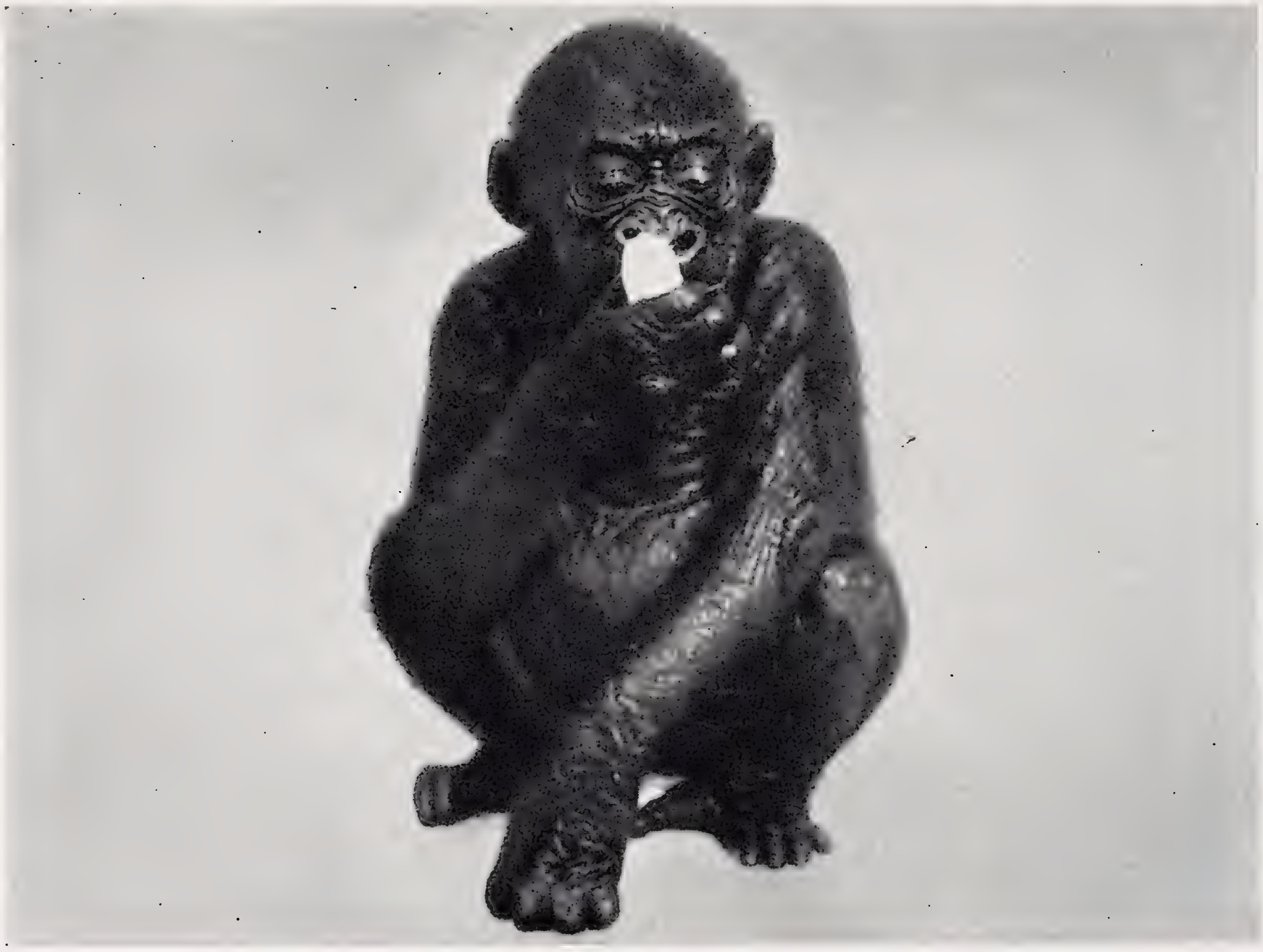

Fig. 5. The emaciated and weakened condition of Penserosa at the time of her arrival is apparent in the accompanying photograph, which was made soon after her arrival, at which time she weighed a trifle over seventeen pounds. A point of interest shown in the picture is the manner in which she balanced herself on the knuckles of her hand.

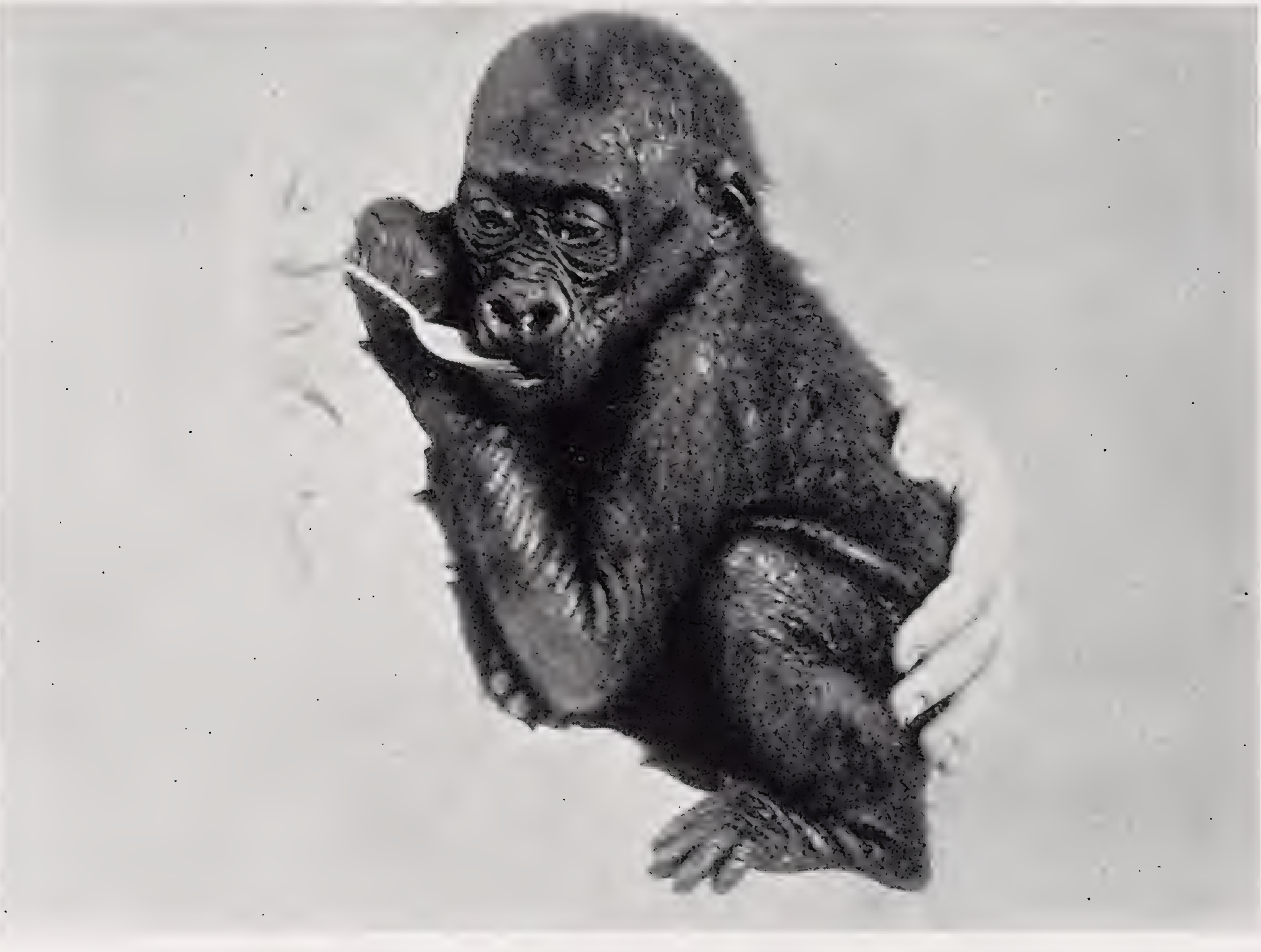

Fig. 6. She was so weak at first that it was necessary to use a spoon in feeding liquid foods, such as milk and eggs beaten together. Cod liver oil, a necessary part of the diet, was also given her in a spoon.

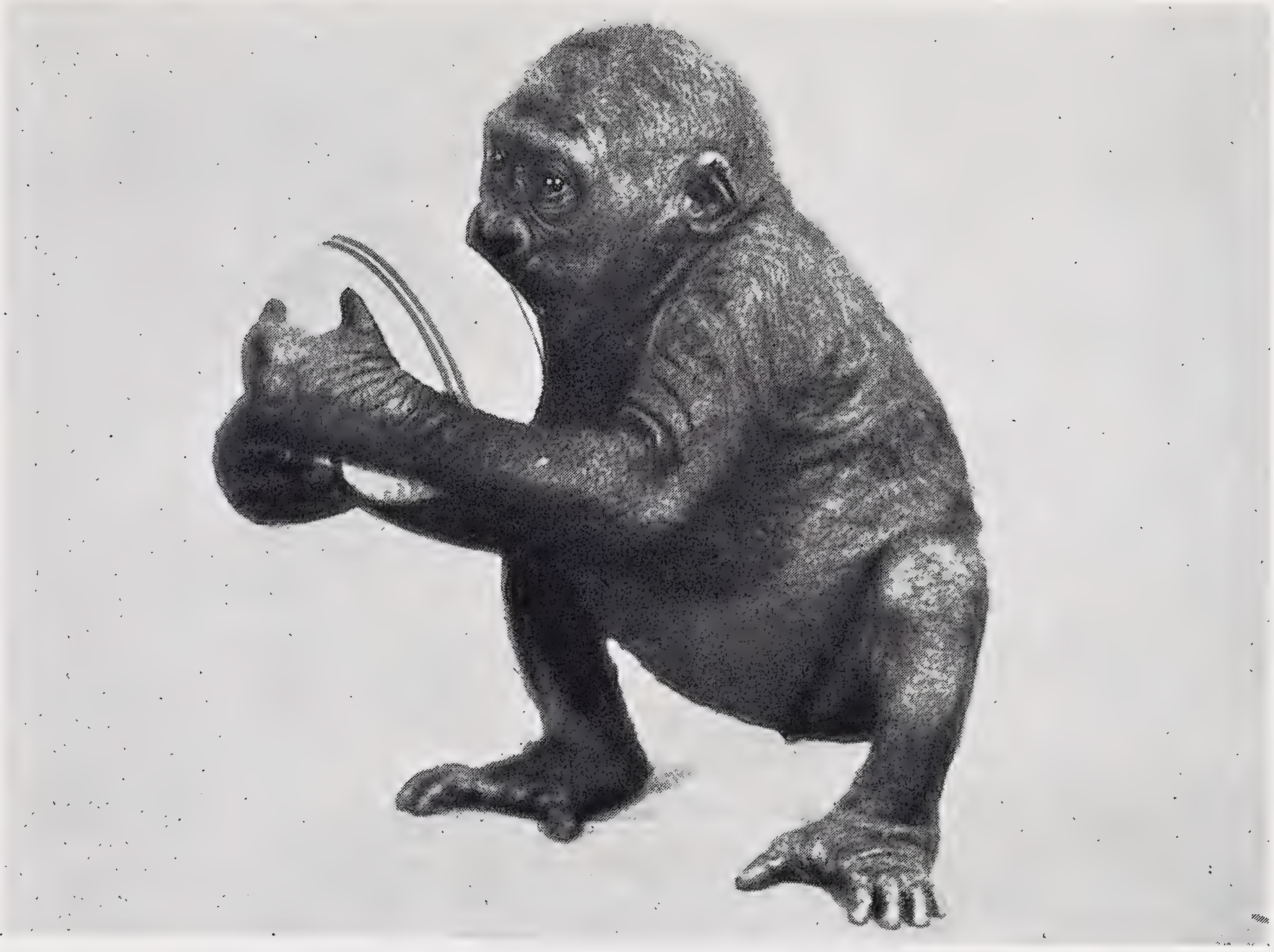

Fig. 7. As she gained in strength, an interest was manifested in toys. She clasped a large rubber ball in her arms as she toddled awkwardly around, but like an infant appeared to be more intent upon chewing upon it than bouncing it about.

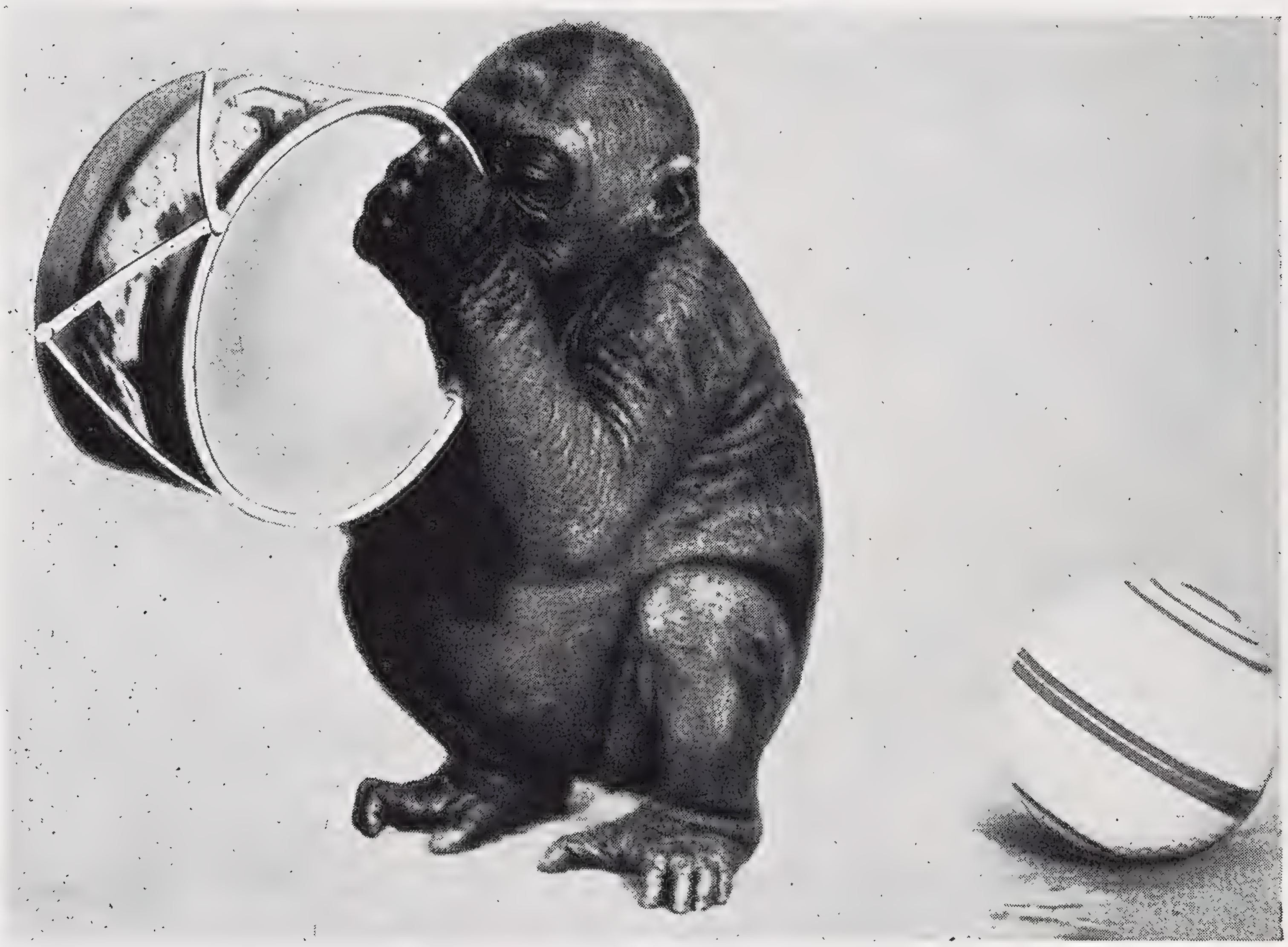

Fig. 8. Occasionally the ball would be discarded in favor of a toy drum, which she treated in the same way. Improvement in her physical condition is evident by her rotund appearance.

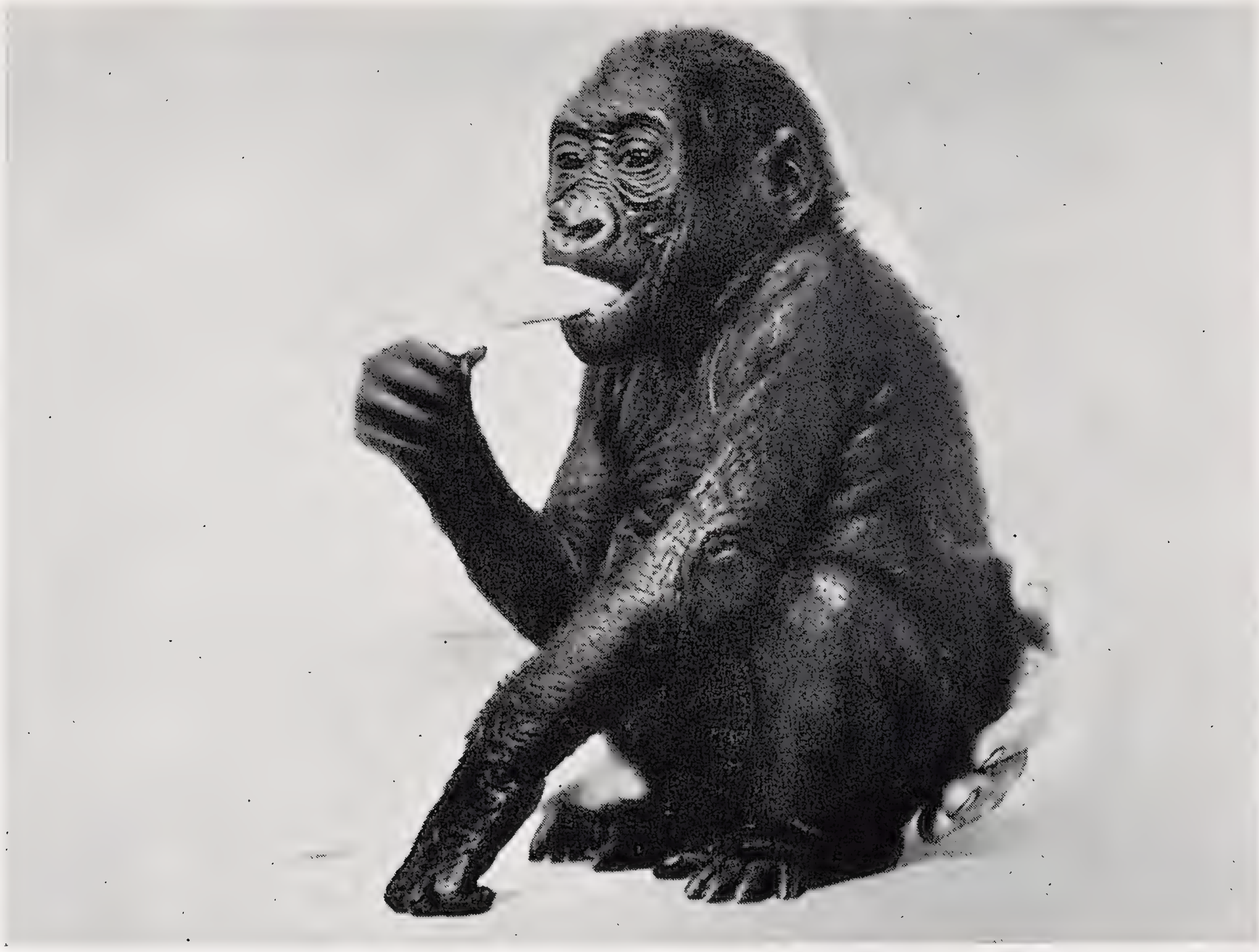

Fig. 9. Bananas are a favored article of food among the great apes, and in the strictly limited dietary of Penserosa this fruit was included. She ate bananas with relish, preferring them, contrary to the tastes usually shown, not too ripe. Toward the middle of December, 1928, when this picture was made, the result of careful feeding was quite apparent.

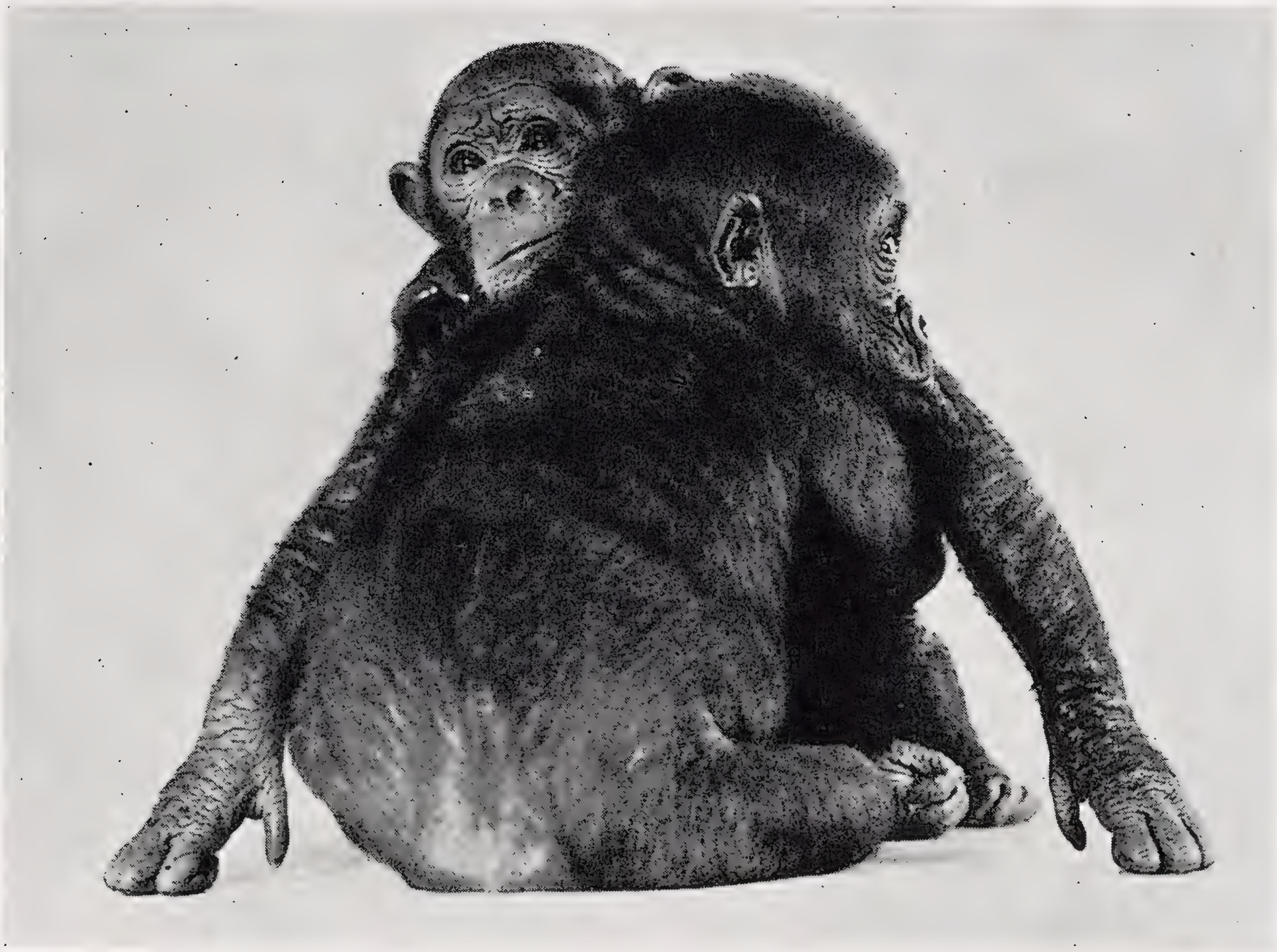

Fig. 10. The infantile state of the young gorilla is well illustrated in the following five pictures. She clings to her chimpanzee companion Allegra, who in turn mothers her little charge, manifesting the true maternal instinct.

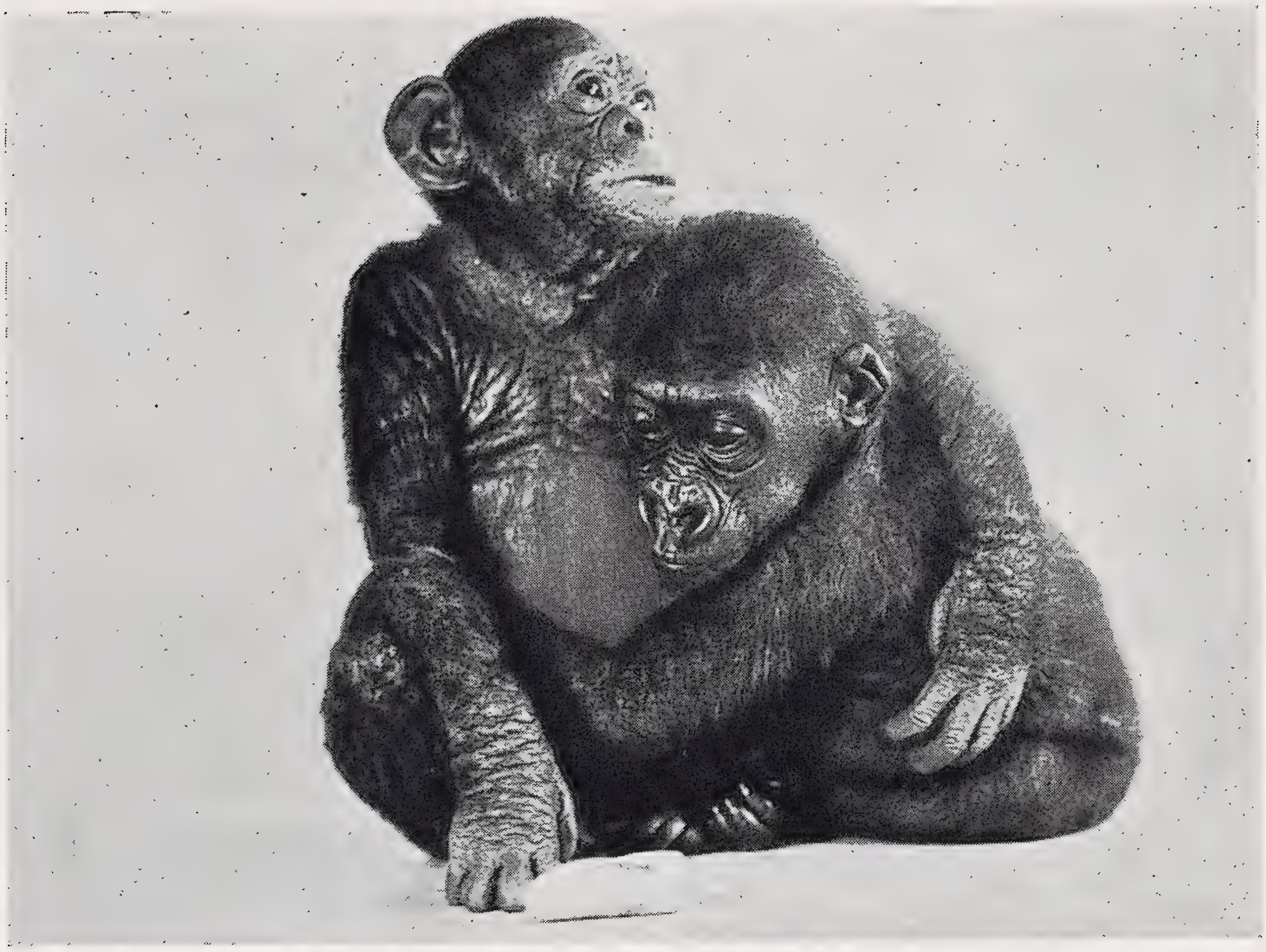

Fig. 11. The courageous Allegra apparently senses a self-imposed responsibility, as she places her protecting arm about her timid companion. An instinct which is often revealed among wild animals.

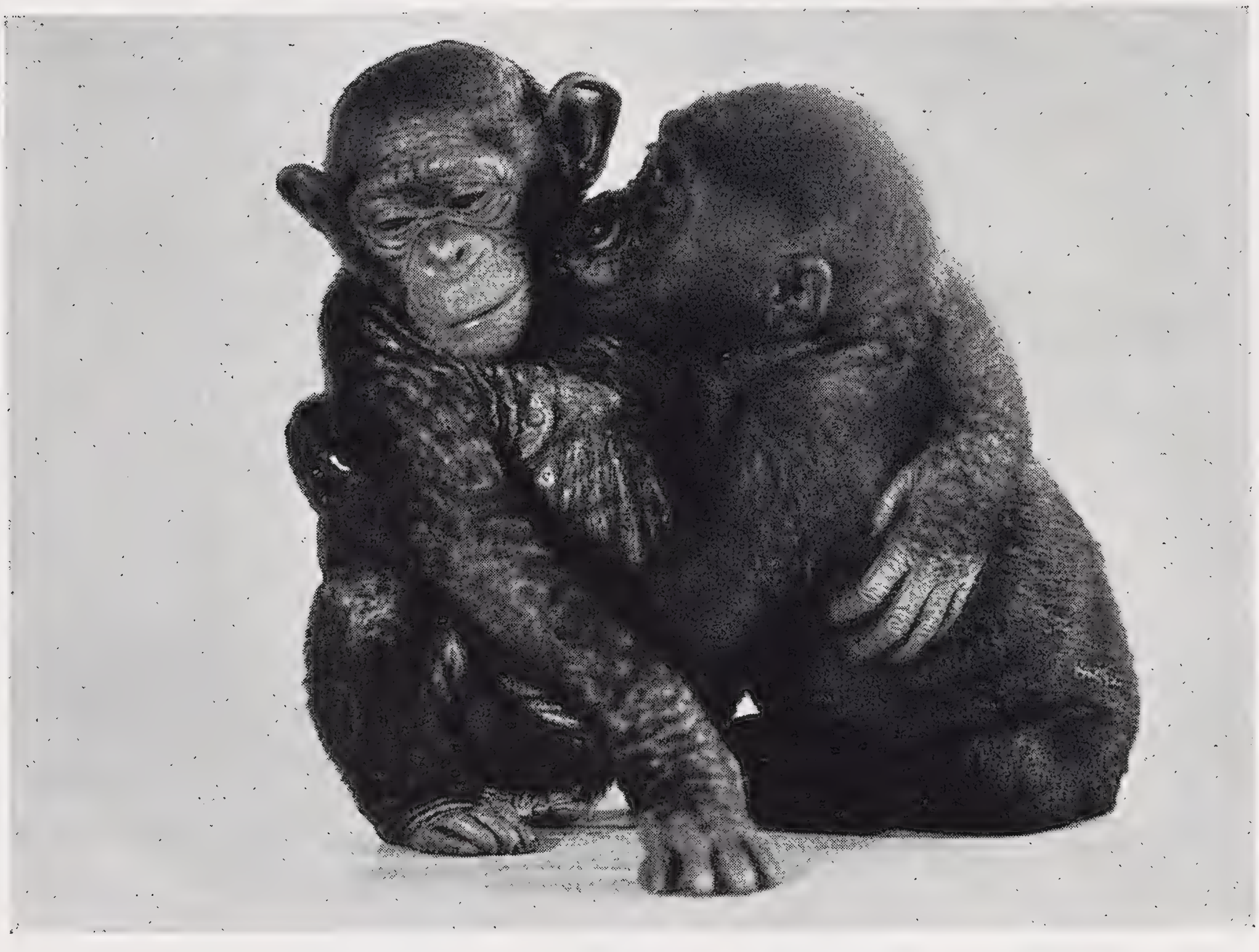

Fig. 12. When strangers arrive, the two little apes invariably cling tightly to each other. The gorilla ever dependent upon the more intrepid and fearless Allegra.

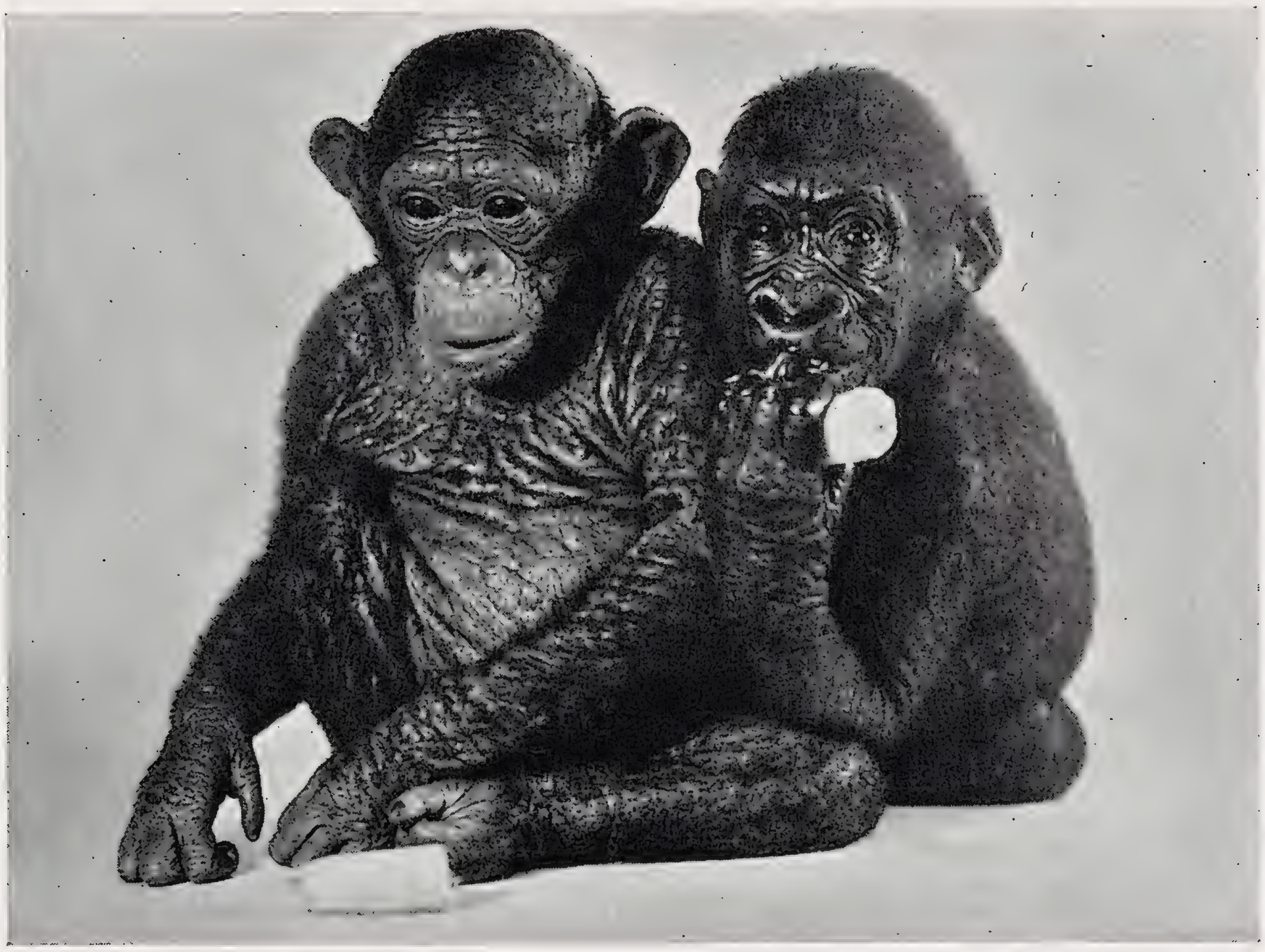

Fig. 13. The ever alert and active chimpanzee is all attention and interested while the gorilla hovers timidly behind her protector, nervously clutching a partially eaten banana.

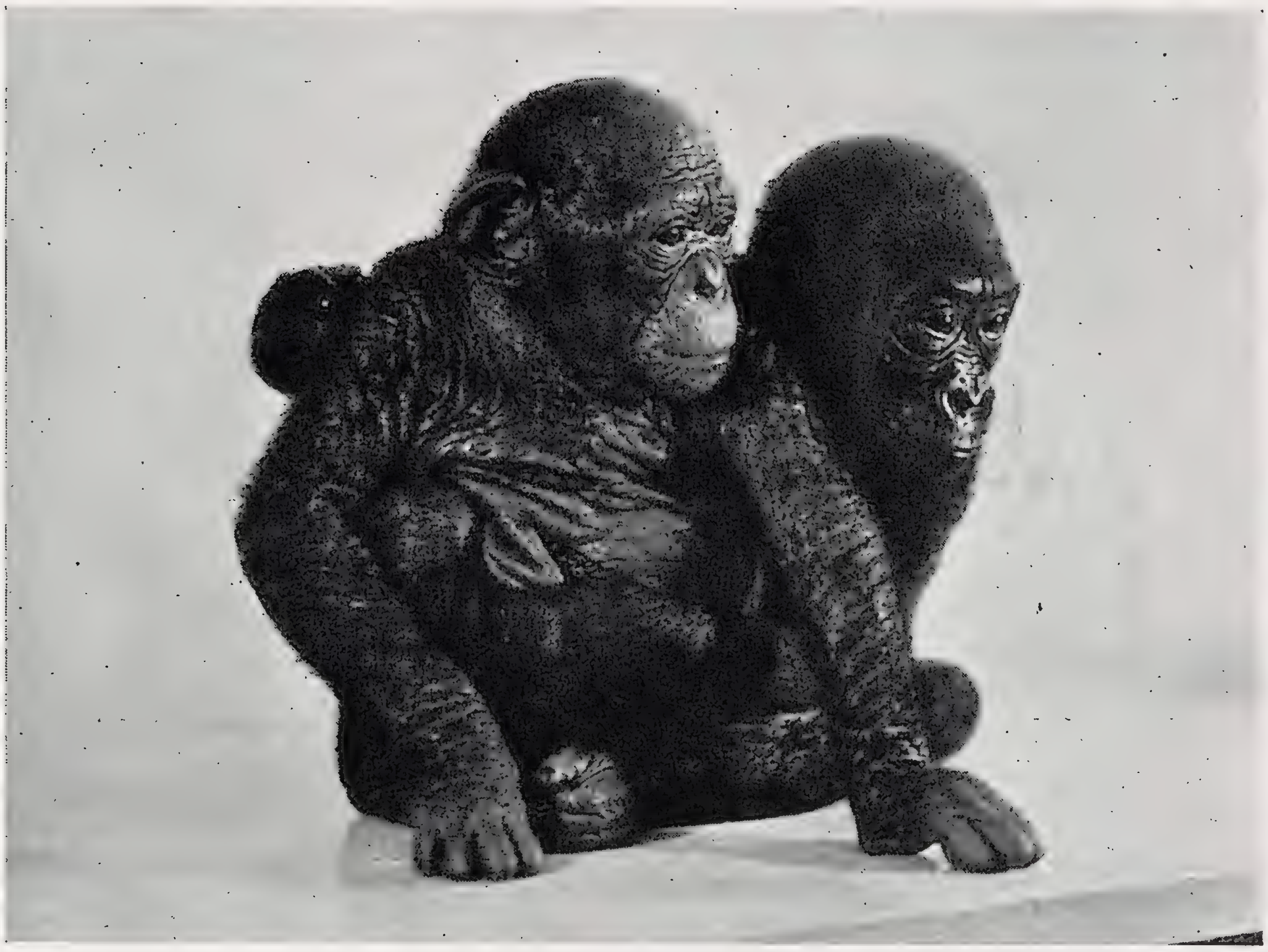

Fig. 14. They sit for the photographer with the same joy as the human. It is an ordeal which they endure with a pose of watchful waiting, seizing any opportunity to slip off the perch and go back to play.

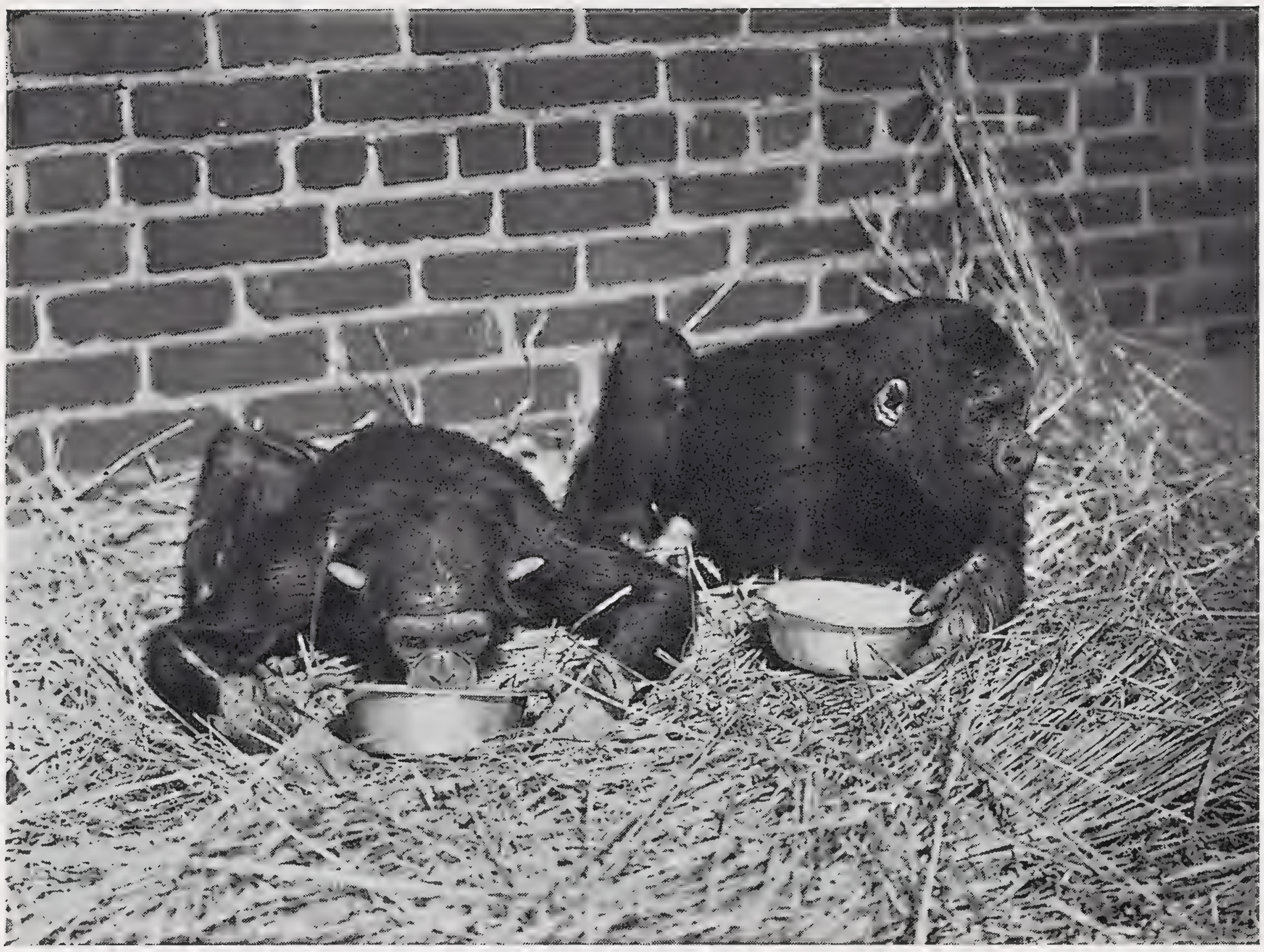

Fig. 15. When eating they present two extremes: the more high strung and active chimpanzee seizes the pan of milk, quickly raises it and speedily disposes of the contents, while the placid gorilla has very leisurely taken the first sip.

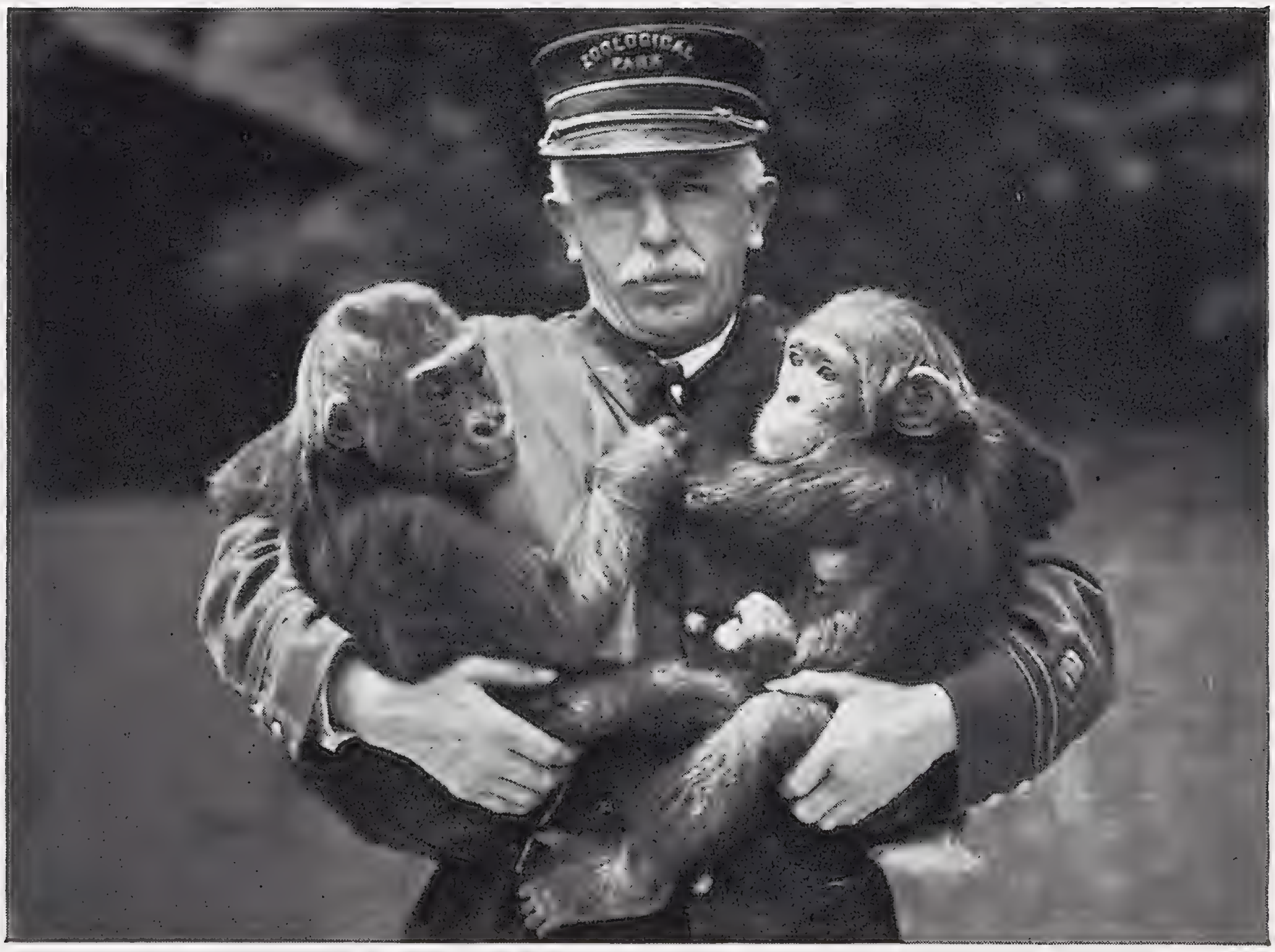

Fig. 16. They were taken out-of-doors for the first time on May 15, 1929, by their keeper. Their condition is reflected in the lustrous condition of the hair and the animated expression of the faces. This is a positive index of increasing good health.

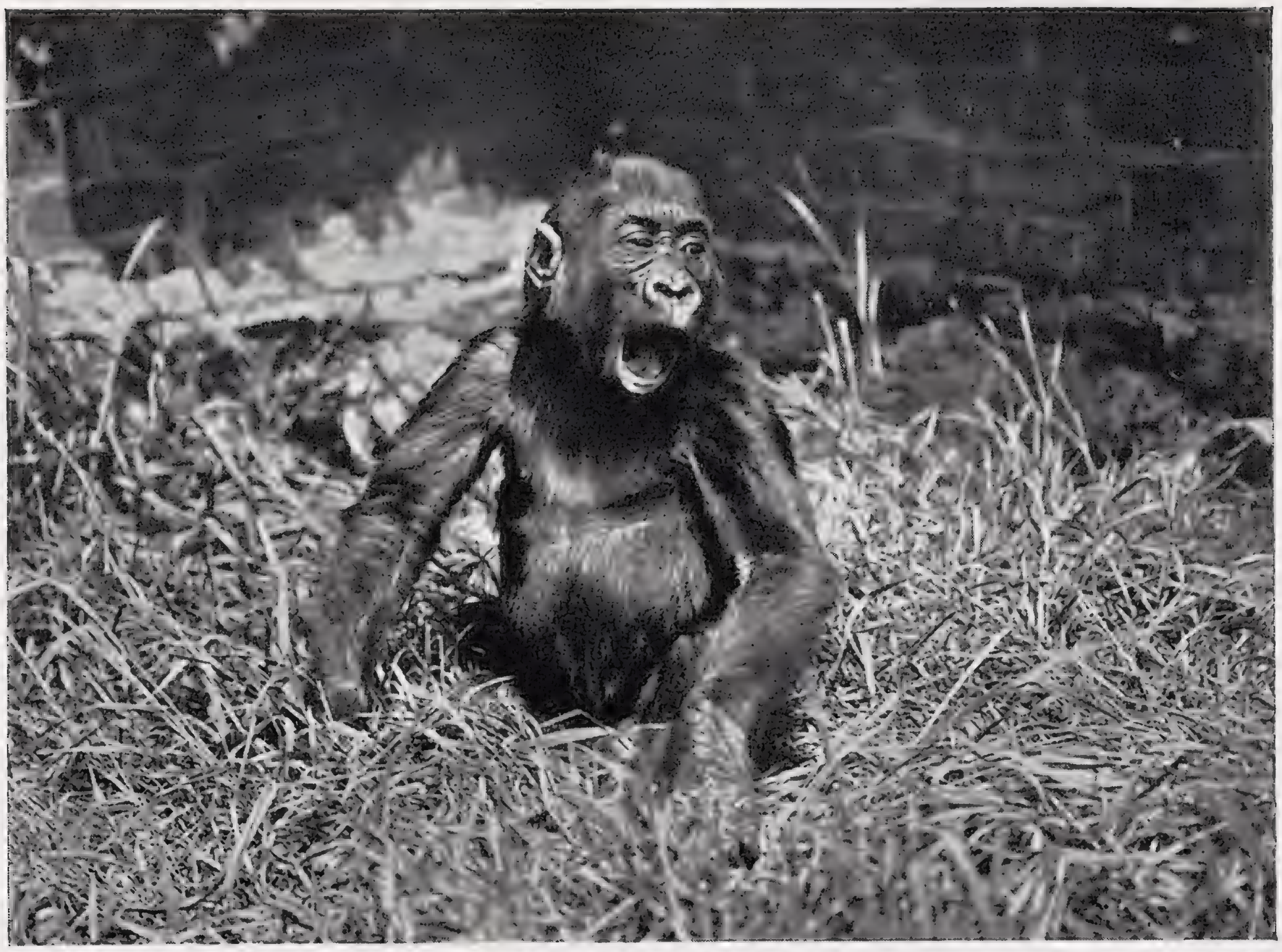

Fig. 17. Both animals were allowed to play in the open like human children. Freedom in the warm sunshine, in which they indulged with tremendous zest, stimulated drowsy relaxation and restful sleep.

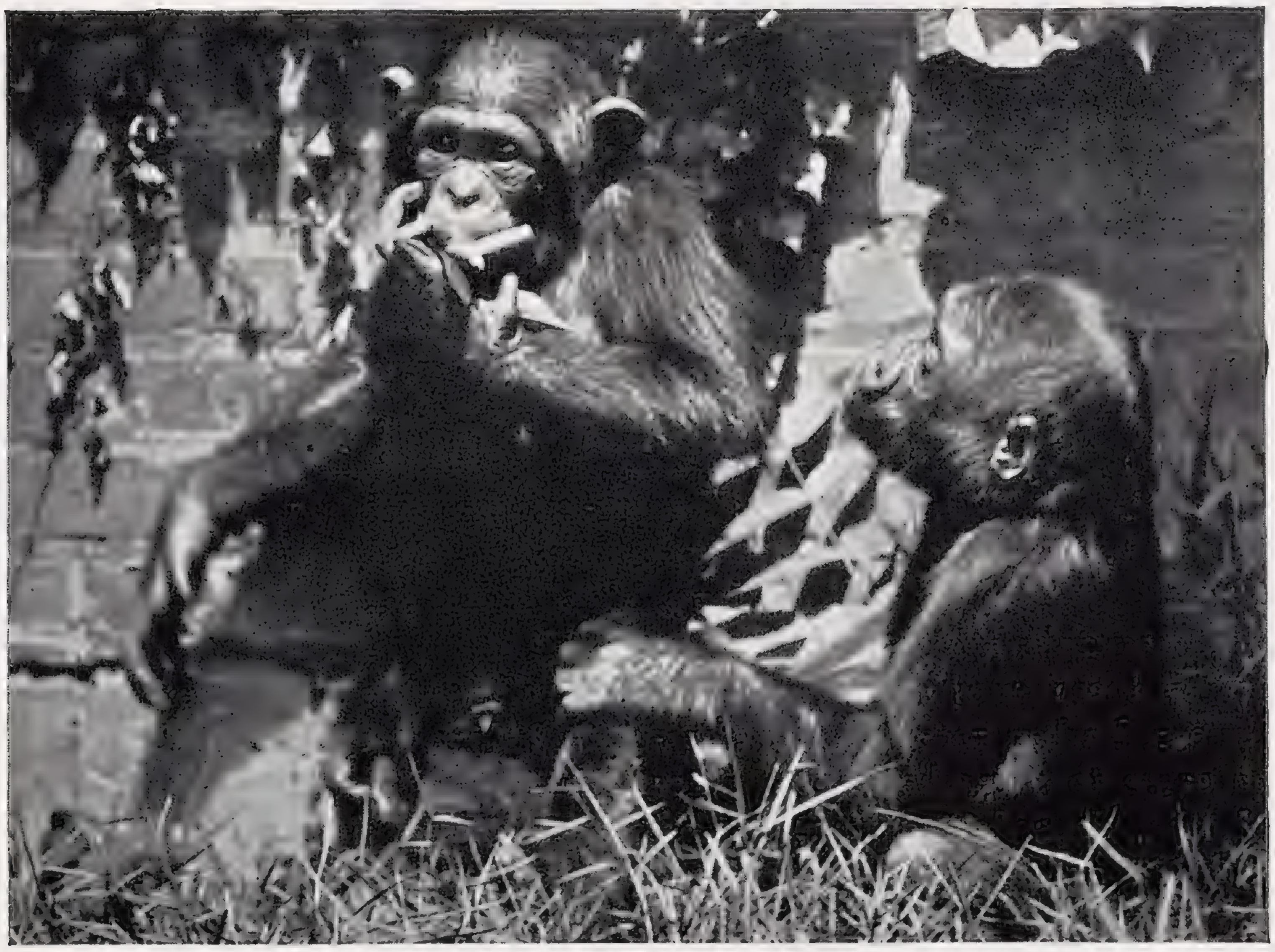

Fig. 18. A branch of fresh, green leaves was both a novelty and a feast. They instinctively enjoyed a return to their natural diet, which they shared impartially and without greed.

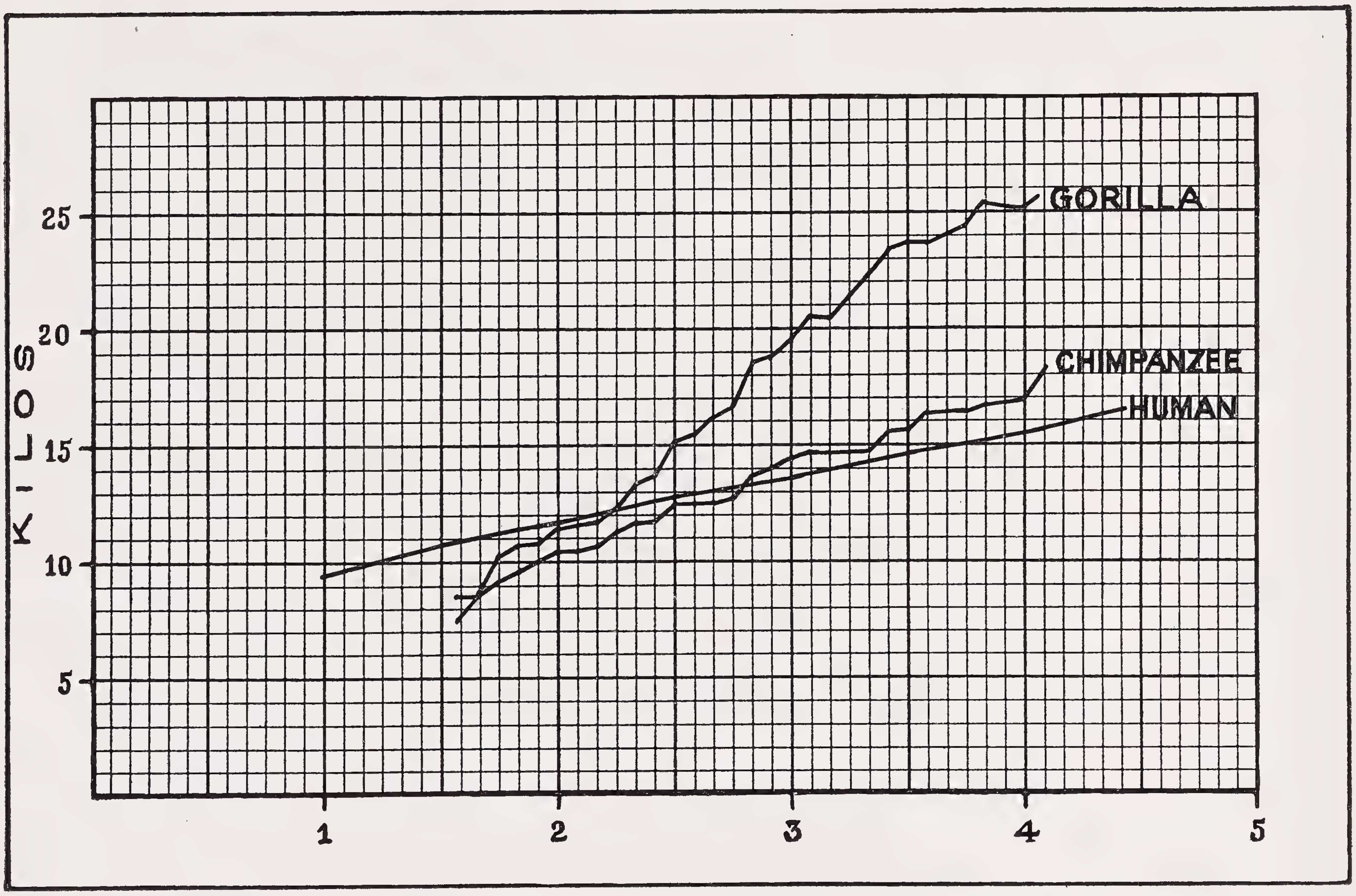

Fig. 19. This chart is a graphic representation of the weight record of the young gorilla and chimpanzee from the time of their arrival, October 31, 1928, to April 16, 1931, over a period of two and a half years. They were estimated as being about 19 months of age on October 31, 1928. For comparison, the average weight record in the human female is also plotted. The figures along the base line indicate age in years, the small intervening spaces representing months. Weight is recorded in kilos. (1 kilo—2.2 lbs.) The chimpanzee's weight-curve closely follows that of the human, while the gorilla's line indicates a rapid increase in body weight.

The baby gorilla gradually became more active and soon climbed about upon the trapeze and danced around on all fours in an awkward, yet rhythmic manner. She grew more friendly and would sit in the keeper's lap each morning and permit herself to be petted. On December 8, 1928, it was noticed for the first time that the baby gorilla climbed up the pole in her playroom. The pole was an inch and a half in diameter and eight feet high. She was apparently learning to climb.

The accompanying photographs which were made a few weeks after these apes arrived, illustrate how they appeared when received at the Park. They also serve to show how the chimpanzee mothered the dependent infant gorilla (Figs. 10, 11, 12, 13 and 14).

During November and part of December, 1928, their condition improved as they slowly gained in weight and strength. Penserosa (Fig. 9), the gorilla, gained in weight more rapidly than the chimpanzee.

On December 4, 1928, she weighed twenty-two pounds, a gain of five pounds since the first of November.

While being fed, the baby gorilla utters a low, soft purring sound. Piteous cries are made when her chimpanzee companion deserts her. If greatly excited, as for example, when one forcibly takes the chimpanzee away into another room, the gorilla will open her mouth, retract her lips, show her teeth and let out a long, high-pitched shriek, like the scream of an angry child.

Because of her slow, deliberate movements, deep-set soft brown eyes, and a serious, sometimes pensive facial expression of her face, suggesting a thoughtful mood, the name Penserosa was given to the infant female gorilla. She had been known as Janet, therefore, her full name is Janet Penserosa.

In contrast to the gorilla, the quick smooth movements, long slender fingers, large ears ready to catch the slightest sound, alert twin-

Age, Estimated	Weighed	Gorilla*	Chimpanzee†	Human Female‡
— months	Oct. 31, 1928	7.84 kilos	8.18 kilos	
20	Nov. 9, 1928	8.93	....	
—	Nov. 18, 1928	8.75	8.98	
21	Dec. 4, 1928	10.00	9.34	
—	Dec. 26, 1928	10.34	9.65	
22	Jan. 15, 1929	10.34	9.86	
23	Feb. 5, 1929	10.68	10.11	
—	Feb. 15, 1929	11.12	10.00	
24	Mar. 2, 1929	....	10.11	11.1 kilos
—	Mar. 28, 1929	11.13	10.22	
25	Apr. 13, 1929	11.47	10.34	
26	May 1, 1929	11.70	10.68	
—	May 22, 1929	11.53	10.68	
27	June 6, 1929	12.30	11.13	
—	June 14, 1929	11.90	11.25	
—	June 24, 1929	12.95	11.25	
28	July 5, 1929	13.18	11.42	
—	July 20, 1929	13.56	....	
29	Aug. 12, 1929	13.86	11.81	
—	Aug. 30, 1929	14.10	11.81	
30	Sept. 10, 1929	15.00	....	
—	Sept. 30, 1929	15.00	12.50	
31	Oct. 11, 1929	15.34	12.61	
32	Nov. 10, 1929	16.13	12.50	
33	Dec. 5, 1929	16.93	12.84	
—	Dec. 27, 1929	17.60	13.30	
34	Jan. 21, 1930	18.30	13.60	
35	Feb. 13, 1930	18.86	13.97	
36	Mar. 7, 1930	19.54	14.30	13.6 kilos
—	Mar. 18, 1930	19.43	14.31	
—	Mar. 30, 1930	19.77	14.43	
37	Apr. 21, 1930	20.45	14.65	
38	May 9, 1930	20.34	14.54	
39	June 2, 1930	21.36	14.54	
40	July 10, 1930	22.20	14.66	
—	July 24, 1930	22.70	15.20	
41	Aug. 12, 1930	23.63	15.40	
42	Sept. 2, 1930	23.80	15.68	
43	Oct. 1, 1930	23.90	16.02	
—	Oct. 20, 1930	24.09	16.02	
45	Dec. 9, 1930	24.65	16.13	
46	Jan. 5, 1931	25.2	16.77	
—	Jan. 26, 1931	25.68	....	
47	....	....	....	
48	Mar. 2, 1931	25.0	17.00	15.2 kilos
—	Mar. 27, 1931	25.79	17.80	
49	Apr. 16, 1931	26.36	18.60	

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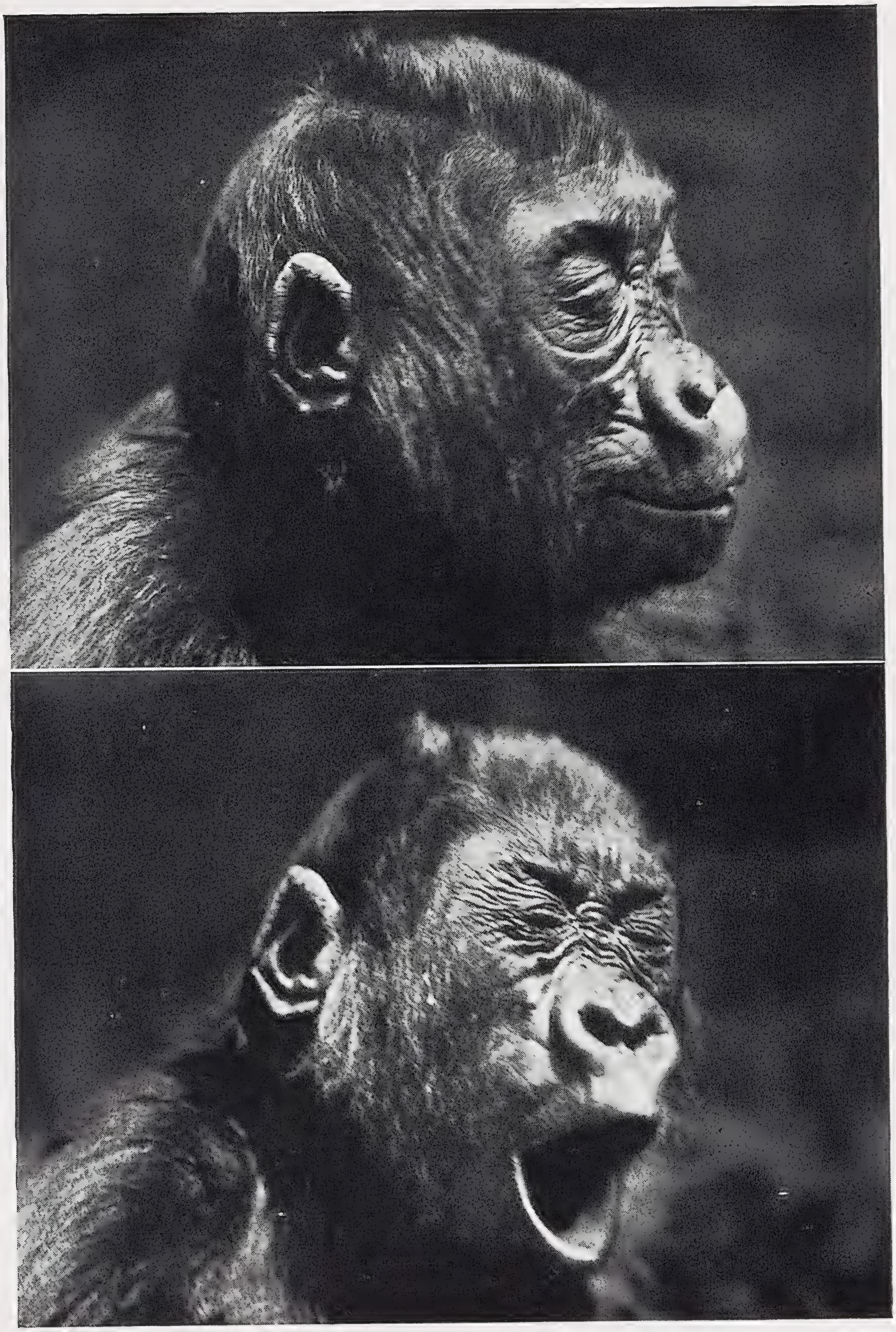
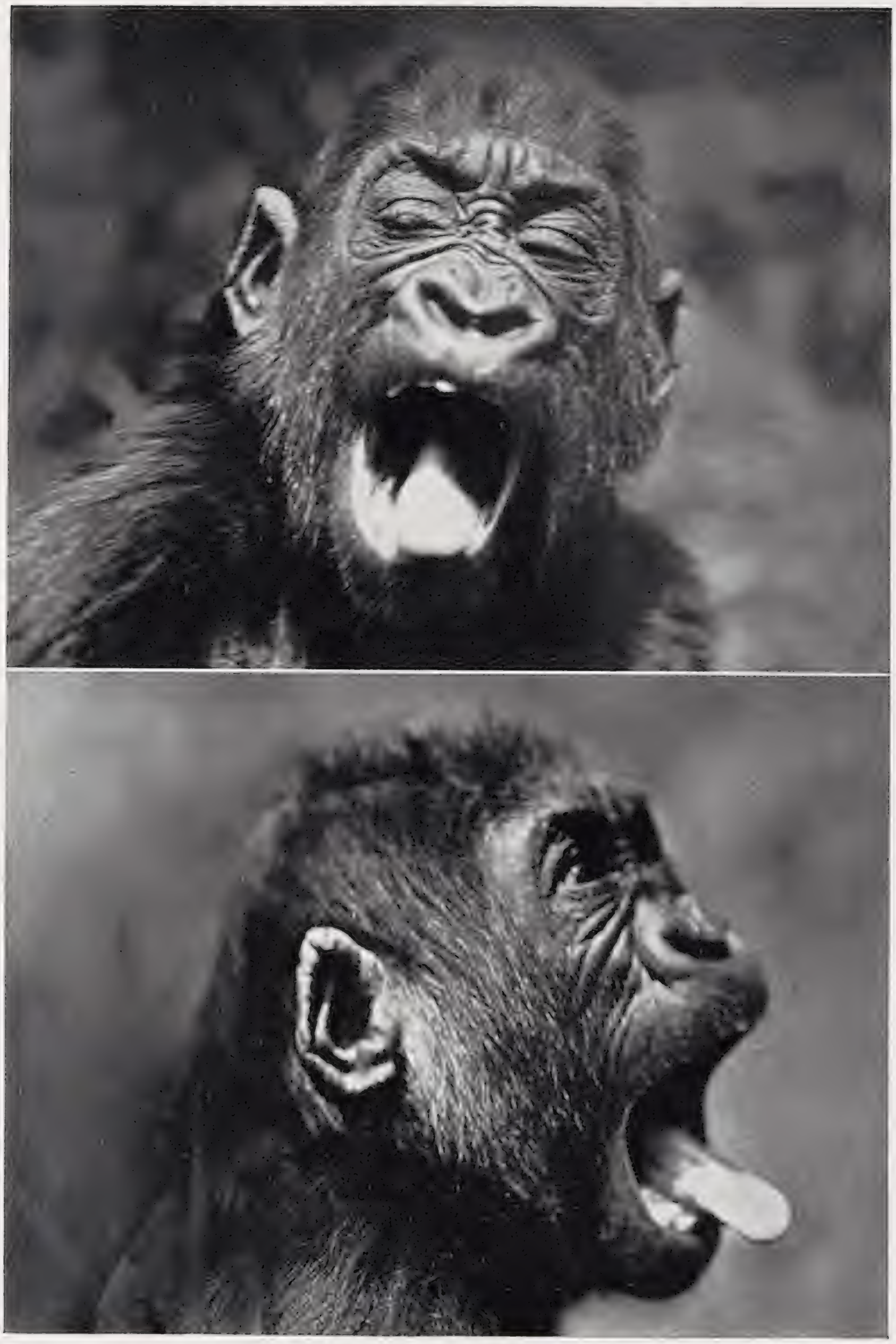
*Penserosa; †Allegra; ‡Human: Weight in kilos. of human (fem.); end of 1st year 9 kilos; 2nd year 11.1 kilos; 3rd year 13.6 kilos; 4th year 15.2 kilos. After C. B. Davenport "Human Metamorphosis", *Am. Jour., Physical Anthropology, Vol. IX, No. 2 pg. 215, and Table C, pg. 229; April-June 1926.*



Figs. 20-21. Four interesting photographs of the changes in facial expression of the gorilla. In repose, grave and solemn, like a serious old man; relaxing with wrinkled brow into a drowsy yawn.



Figs. 22-23. The very peak of a yawn. Not so very beautiful, but indicating complete lazy satisfaction. At the finish, Penserosa comes to life, showing in her countenance a curious mixture of awe, surprise and bravado.

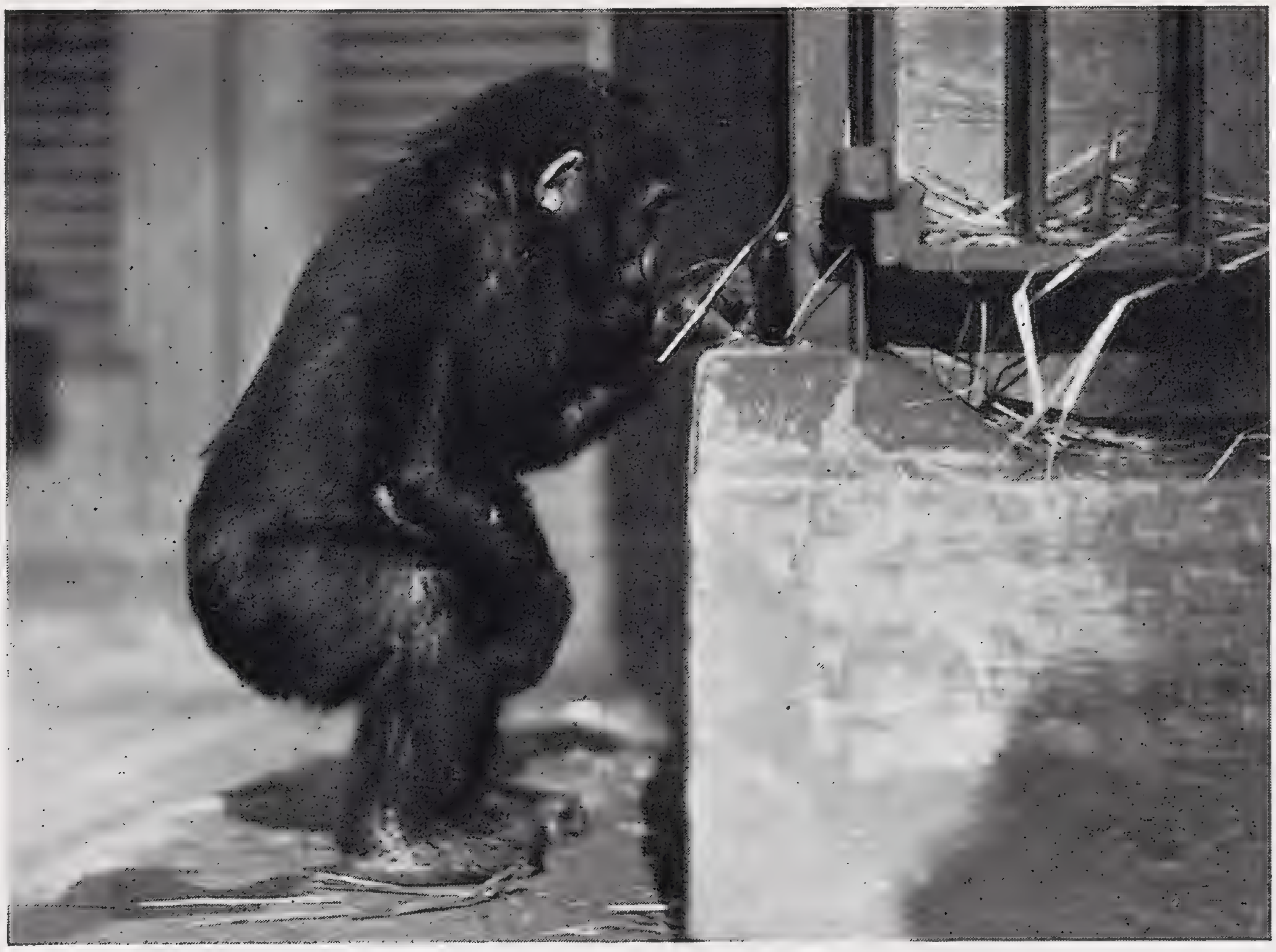


Fig. 24. Both the gorilla and chimpanzee have been allowed access to their out-door cage in the coldest winter weather. Penserosa is shown in this picture with the temperature below freezing, nibbling bits of ice. Life in the open air had developed a heavy coat of hair.

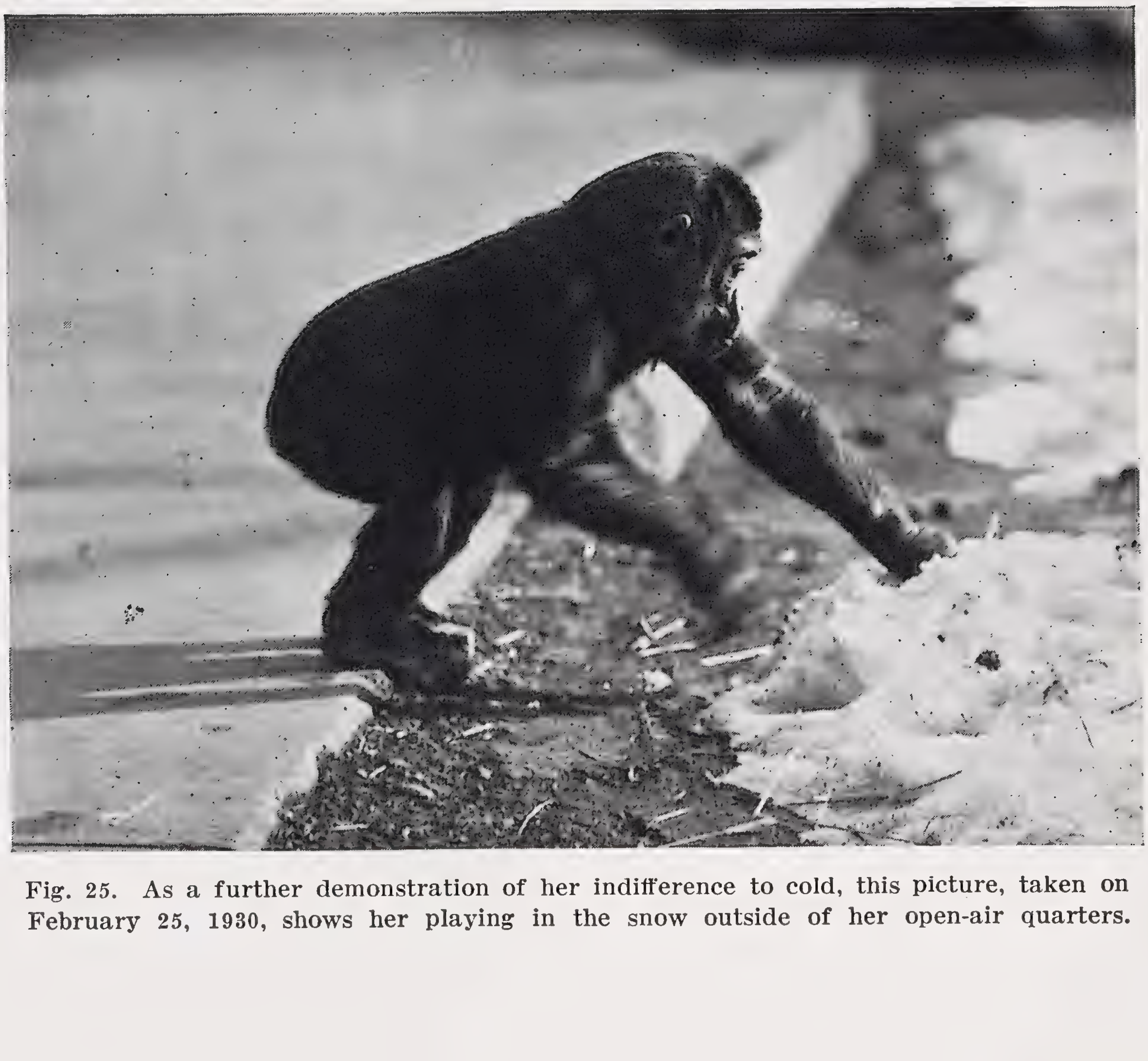


Fig. 25. As a further demonstration of her indifference to cold, this picture, taken on February 25, 1930, shows her playing in the snow outside of her open-air quarters.

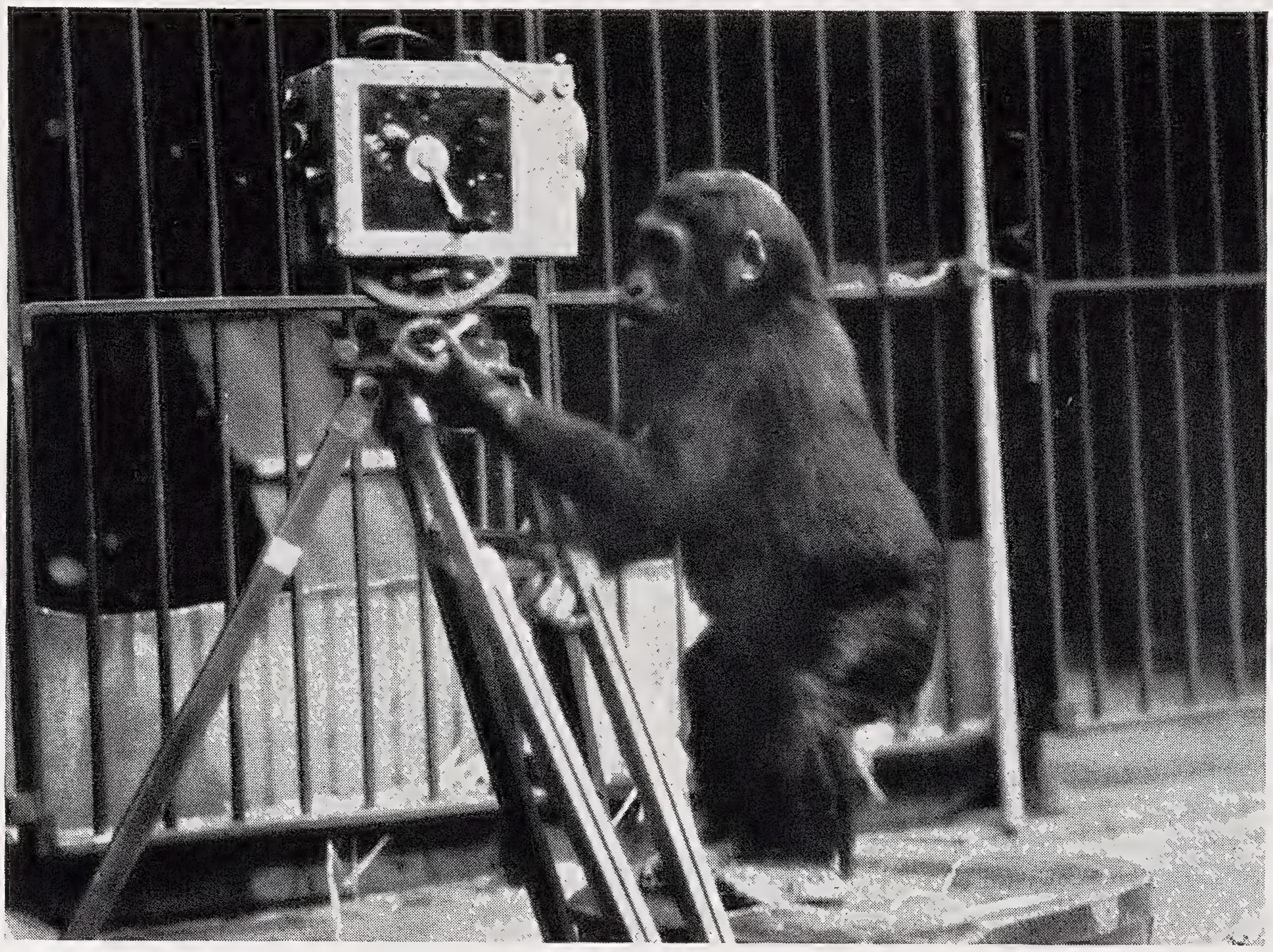


Fig. 26. All of the great apes manifest a consuming curiosity for any mechanical object and display at times great intelligence in attempting to solve the intricacies of its construction. She was instantly attracted by the crank operating the tilt of this camera, which she turned.

kling light brown eyes, and a cheerful, mischievous facial expression suggested the name Allegra for the young chimpanzee. She had been known as Ellen, therefore, her full name is Ellen Allegra.

Toward the end of December, 1928, Penserosa appeared depressed and feverish with symptoms of conjunctivitis, congested eyes, rhinitis and general malaise at first, which later developed into an attack of bronchopneumonia. Treatment consisted largely of rest, medication, and the use of dry heat from an infra red lamp which appeared to relieve congestion. During this illness she became so weak that it seemed she was destined to meet the fate of most young gorillas brought to civilization, i. e., to become a victim of pneumonia.

About the middle of January, 1929, recovery seemed assured as she gradually began to play again. Her weight on January 15, 1929, was twenty-two and three-quarter pounds.

The inflammatory skin disease, dermatitis, cleared up under treatment. Her hair began to grow out in short, stubby bristles, which soon became long smooth hairs.

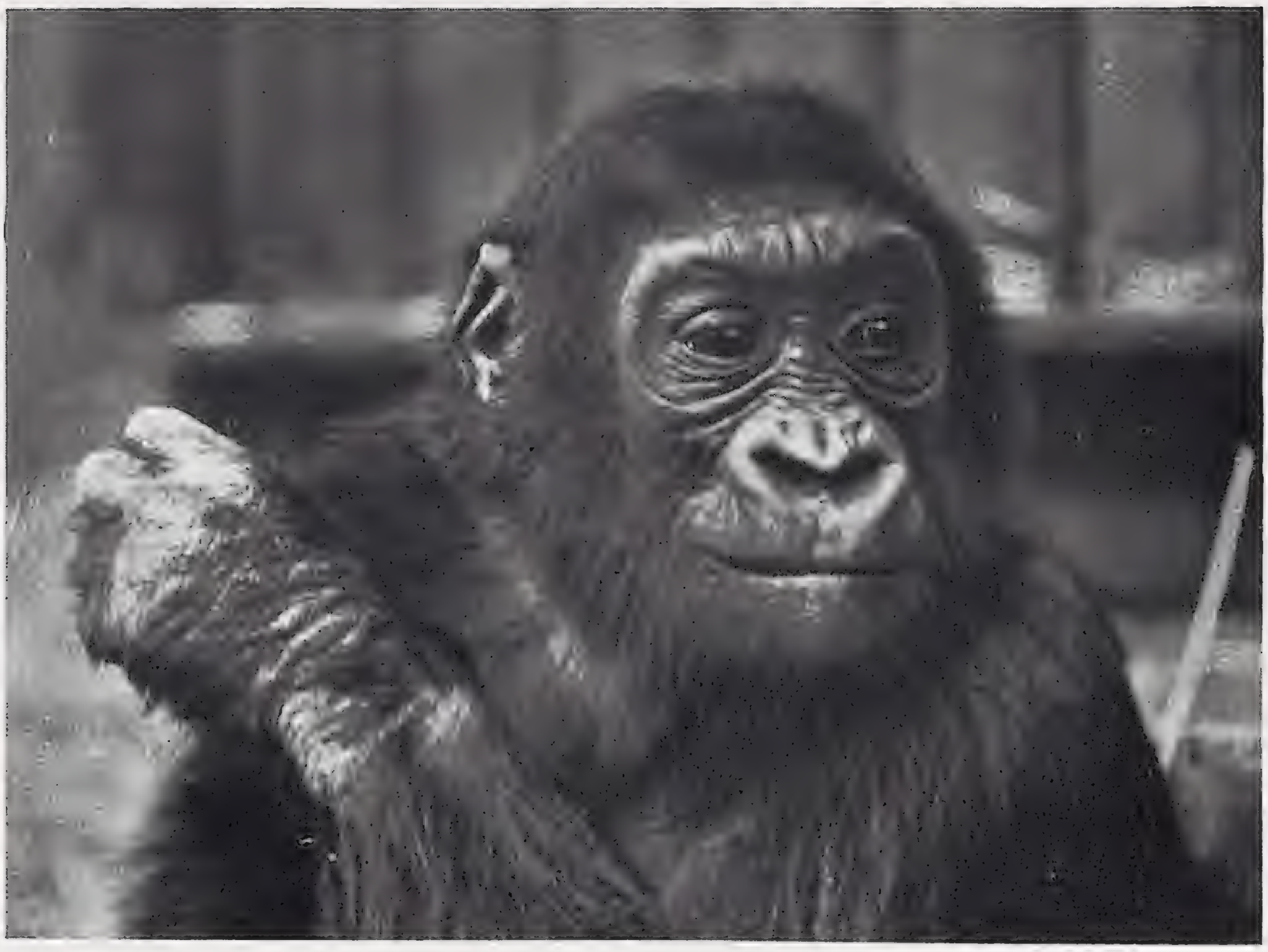
On February 10, 1929, the wrist of Penserosa's right hand became quite tender, painful, and somewhat swollen, and arthritis was suspected. Radiographic examination was negative, the bones appearing normal.

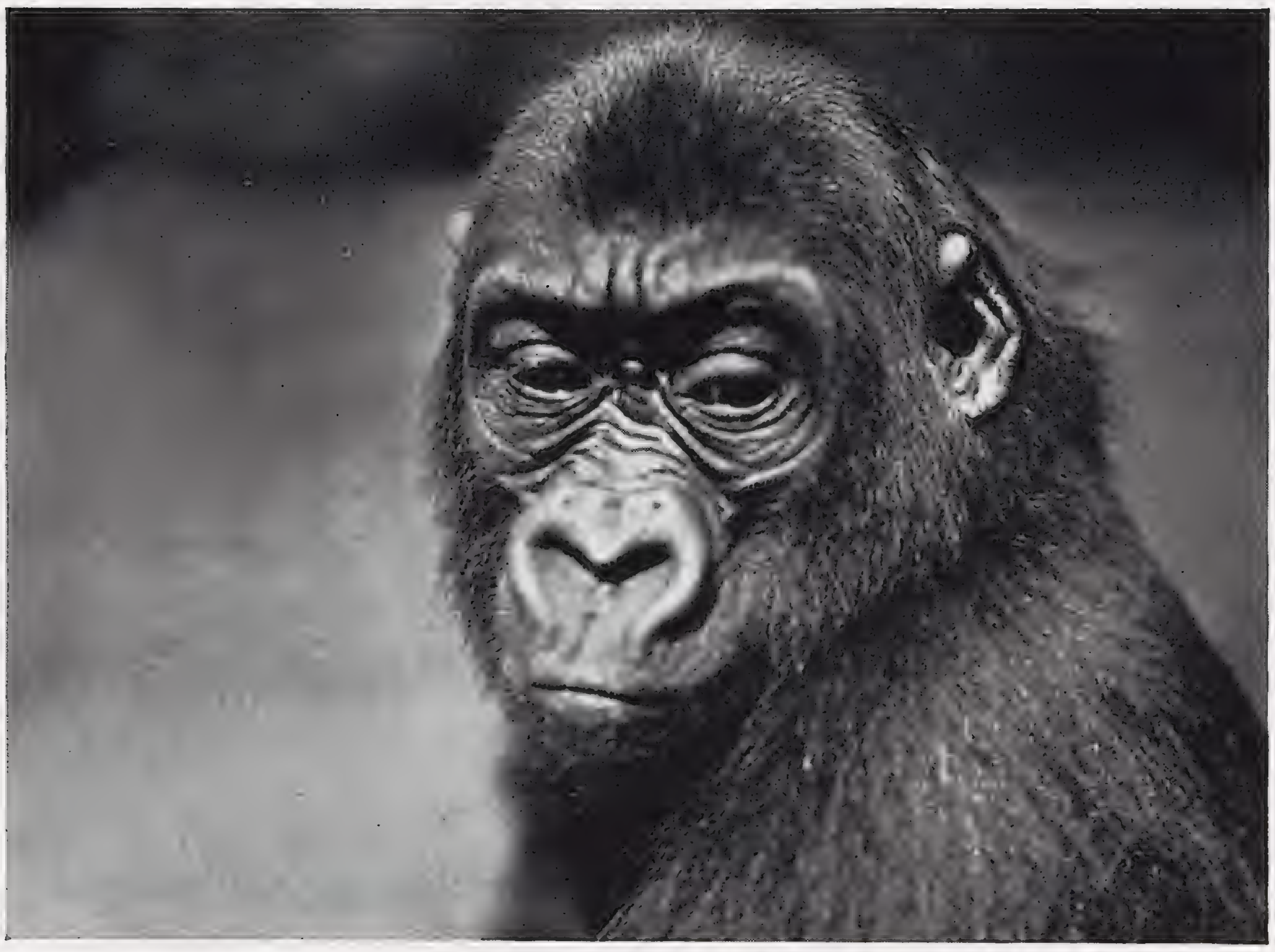
From this date on she remained in good health. The temperature of the Hospital was kept at 65° F. (18° C.) to 78° F. (25° C.) As mentioned previously in this article, she was kept indoors during the winter of 1928 and early spring of 1929.

Despite the rough journey in the fall of 1928 and the setback of pneumonia in December and January, 1929, her general condition continued to improve.

With the approach of spring as the outdoor weather was becoming milder and more pleasant, it was planned to permit the baby gorilla and chimpanzee obtain the benefit of being out of doors during the day. Accordingly, on May 28, 1929, Penserosa and her chimpanzee companion, Allegra, were permitted to play on the lawn in the Hospital yard. A bank about eight feet high with a gently sloping side covered with a grass lawn adjoins the yard, and on the top of the bank are several small trees and shrubs, among them a wild cherry and a small sweet gum tree.

When first brought out of doors Penserosa





Figs. 27-28. These pictures were made in February and September, 1930, and show the rapidly maturing facial development, and the thick coat of hair, which indicates her vigorous state of health by the glossy appearance.

stood still on all fours, resting on the knuckles of her hands and the soles of feet. She curiously cocked her head to one side and tried to locate the source of the song of a chirping bird in a nearby tree. Then she awkwardly romped about on the lawn, climbing up the bank to a small black birch tree, and ate some young leaves and bark. She apparently enjoyed her first day out of doors.

The use of artificial sunlight—the ultraviolet light from a mercury vapor lamp was discontinued as they were now to receive the benefit of natural sunlight.

A large double cage consisting of an indoor and an outdoor compartment separated by a sliding door, was provided for them. A bench and trapeze were installed, after which the gorilla and chimpanzee were transferred to their new quarters each day. From this time on they had access to the outdoors at will during their waking hours while at night they were returned to their sleeping cage.

Feeding time offers an opportunity to observe some general behavior characteristics of the gorilla and chimpanzee. They awaken around six or seven o'clock each morning, tumbling and wrestling about in the straw of the sleeping cage for an hour or more. About half past seven their keeper enters the hospital kitchen to prepare their morning meal. While their food is being prepared the clatter of aluminum pans and the whirring sound of the egg beater can easily be heard in the Hospital.

The alert, restless chimpanzee is constantly on the move, jumping, crying, and climbing about the cage anxious to get her share as she finally directs her eyes toward the kitchen. The keeper enters with a pan of milk and as soon as it is placed on the floor of the cage the chimpanzee, Allegra, seizes it and hurriedly drinks her portion. In a few minutes she has finished her morning meal.

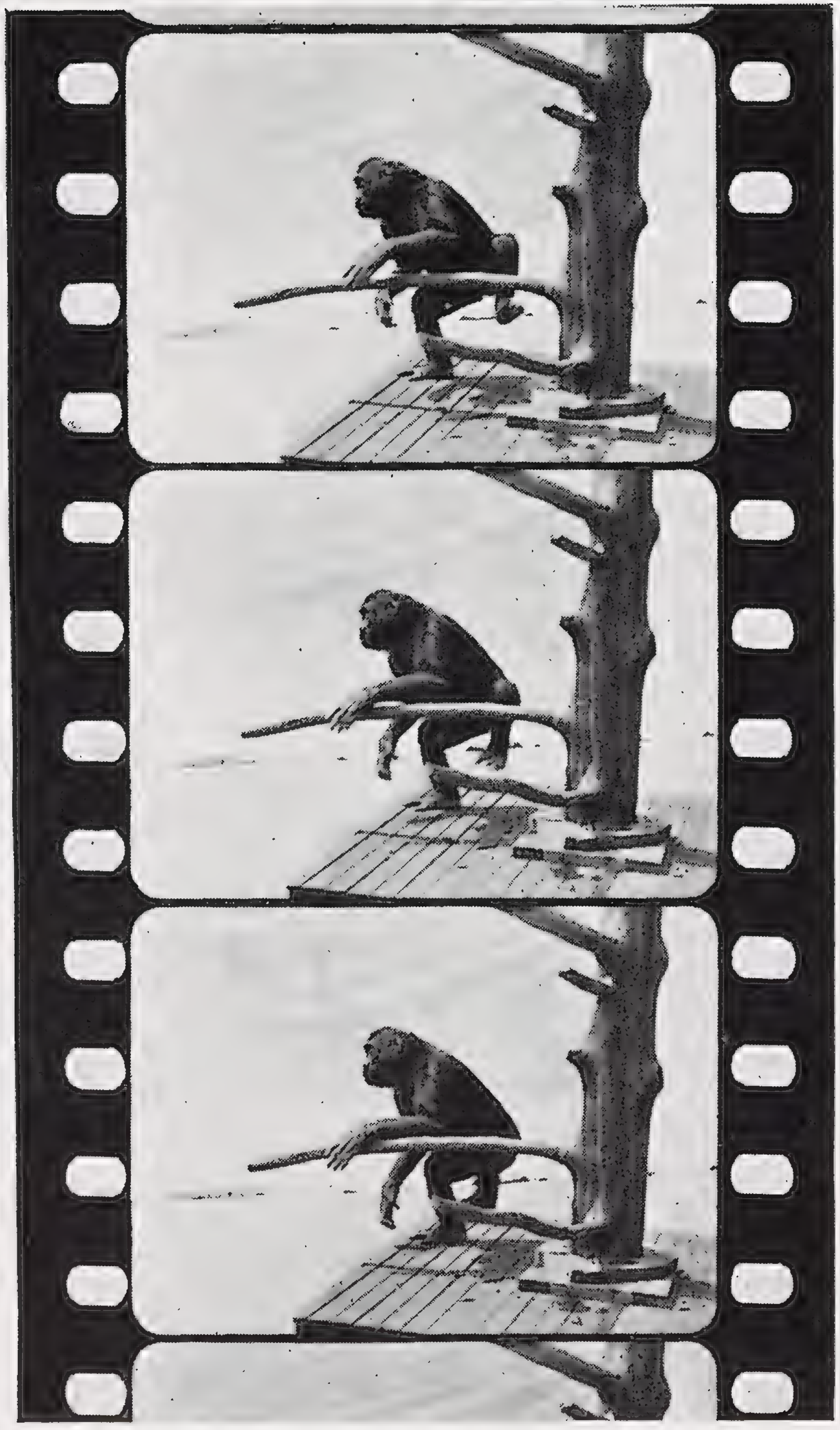
The gorilla, Penserosa, on the other hand, moves about cautiously and with the exception of a single glance toward the kitchen, is undisturbed as she rolls about the straw or plays with her fingers and toes. When her pan of milk is offered to her, Penserosa will frequently pay no attention to it, or she may simply glance at the milk and continue to go on her way, climbing about the cage or even lightly beat her chest. After a pause of a few minutes she will lie down on her abdomen in a comfortable position (Fig. 15), take the pan in her hands, deliberately and slowly drink some of the milk, stop, leisurely look about her, make a low-pitched purring sound, then finally finish drinking the milk. Frequently it is necessary to coax or cajole her before she will take her portion.

Between half past twelve and one o'clock the keeper feeds them in the large outdoor cage, except during rainy weather, when they are fed indoors. As the time for feeding approaches, Allegra the chimpanzee is as agile and active as ever and as soon as she hears the keeper approaching with the large pail of fruit and vegetables, she often cries and screams.

Penserosa, the gorilla, is as quiet and retiring as usual although she may purr or make a sound which resembles a deep, subdued growl.

When the bananas are given to the chimpanzee she seizes them one by one and soon has more than she can hold. Then she begins to hoard them in a corner of the cage and refuses to allow the gorilla to take any. If the keeper gives the gorilla a banana, the chimpanzee immediately takes it away. The gorilla is fed in a separate part of the cage away from the chimpanzee, whose hoarding activities prevent the slow-acting gorilla from getting her share of food. If, however, the gorilla is very hungry she will fight the chimpanzee and refuse to give up her bananas.

Improvement in the physical condition of Penserosa continued steadily as can be seen when we compare the photographs made at the time she was received with those taken in June 1929 (Figs. 16, 17, 18), eight months later. Her chimpanzee companion also improved but the gorilla showed a more marked gain in weight for on June 14, 1929, the gorilla weighed twenty-six and one-quarter pounds (11.9 kg.) while the chimpanzee weighed twenty-four and three-quarter pounds (11.25 kg.). When comparing them it must be taken into consideration that the gorilla is the larger and heavier, an adult of the species weighing over four hundred pounds while the adult chimpanzee attains a weight of from 160 to not more than 200 pounds. The significance of the weight increase seems to be that both were approaching a normal condition after overcoming the setbacks due to travel and ill-



ness. The graph (Fig. 19) on page 88, indicates the progress in the total body weight of Penserosa and Allegra in comparison with the weight curve of the infant human female. While it appears from this chart that the gorilla gains more rapidly in total body weight in comparison with the chimpanzee and human, the record is presented simply as an observation, but no generalization is made at the present time.

Outdoor exercise with rest and relaxation by basking in the warm sunshine aided materially in maintaining their improved condition. The young gorilla's facial expression reflects her moods. Figure 20 illustrates her usual serious mood, while her response to the soothing effect of a balmy June day is expressed by a yawn of relaxation as illustrated in the series of three photographs (Figs. 21, 22, 23) which were made on June 14, 1929.

Penserosa was becoming more self reliant in that she could be separated from Allegra and would play on the lawn, climb the small cherry tree, eat buds, young leaves, and remove the tender young bark from the slender branches of the wild cherry tree by skinning it off with her teeth. Later branches and twigs of the sweet gum tree were given to her and she enjoyed eating the young leaves and buds of this plant also, but was very fond of the fruit burrs of the sweet gum.

The hot, sultry days of the New York midsummer depressed the gorilla more than her chimpanzee companion. Penserosa would lie and pant on very hot days and drink considerable quantities of cold water. On July 20, 1929, beads of sweat were seen rolling down her face, but except under her arm pits, her body was dry. As she did not exercise strenuously, it cannot be definitely stated that visible perspiration does not take place on other parts of the body.

A luxuriant coat of hair, steady gain in weight, clear eyes, clean pink mouth with sound white teeth and healthy gums reflected the beneficial effect of sunlight, fresh air and wholesome food.

It may be recalled that she had been kept indoors during her first winter at the Park, due to her weakened condition at the time of her arrival. Notwithstanding the use of artificial

sunlight and the special care in keeping her in a warm environment she suffered from the effects of a "common cold" and the sequellae of broncho-pneumonia.

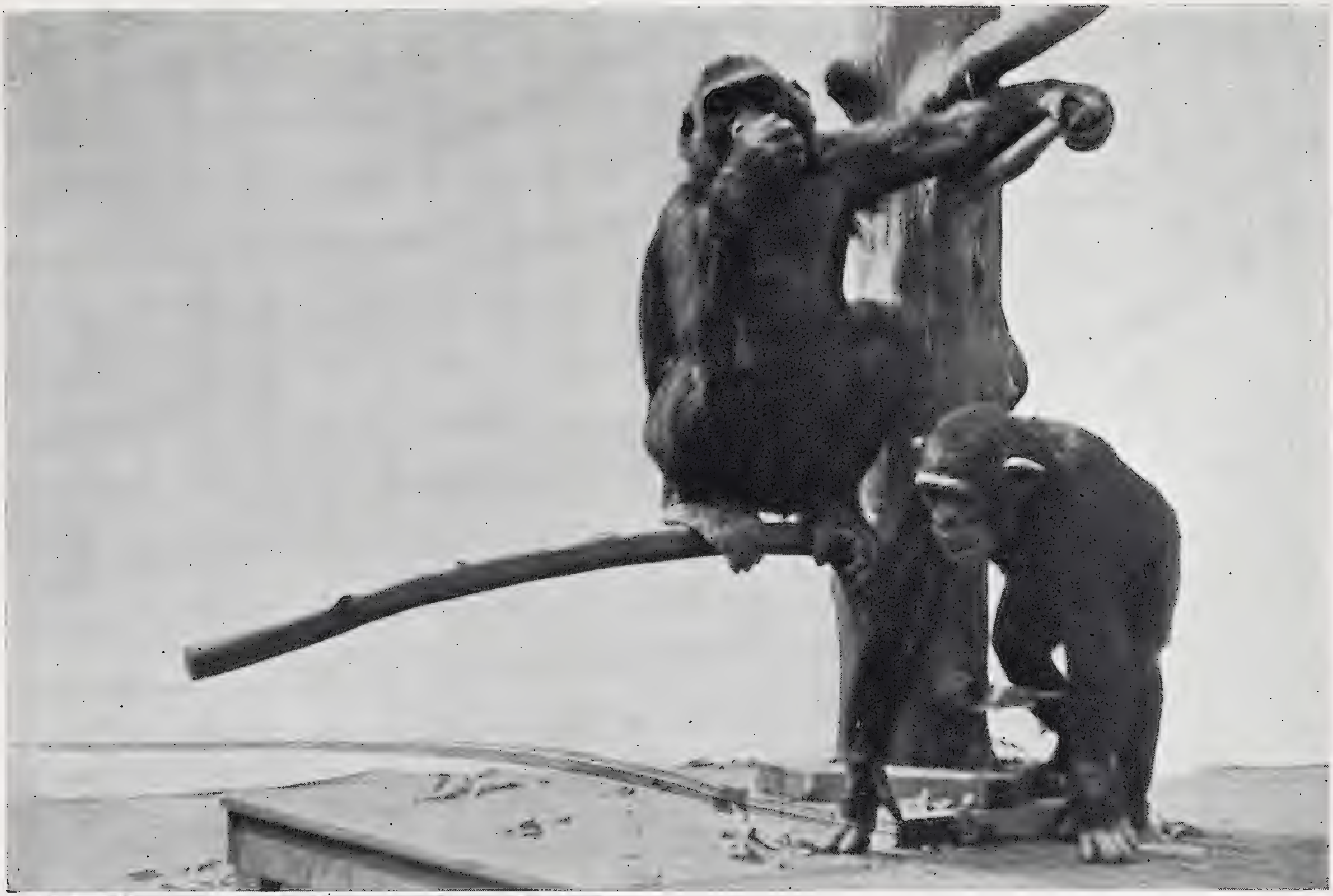
In their native state gorillas may be exposed to a wide range of climatic conditions. Those found in the Cameroons live in hot, humid jungles during the wet season. Those found in the foothills and along the mountain sides are exposed to varying temperatures, especially at altitudes of 4,000 to 6,000 feet, where low temperatures are prevalent at night. The so-called mountain gorilla of the Kivu Mountains is covered with long, shaggy hair which protects it from the cold of high altitudes.

It has been the usual practice at zoological parks to keep captive young gorillas in artificially heated quarters during winter weather. As autumn was passing plans were being considered as to how Penserosa should be cared for during the approaching winter of 1929-1930. Whether to keep her in heated quarters or to send her to a milder climate like that of Florida or Cuba were considered as possibilities.

Since she was in good condition and enjoyed being out-of-doors during the daytime, and because gorillas in their native state may be exposed to cold weather, it was decided to let Penserosa get the full benefit of the early winter sunlight and outdoor air. Penserosa and Allegra were therefore given free range of the combination in- and outdoor cage from morning to night. The indoor cage, however, was provided with hot-water heat.

They thus continued to remain out-of-doors during September and October, apparently happy and contented. The cool crisp October air had an exhilarating effect on Penserosa as she romped about the cage, clapping her hands, beating her chest, or at times dancing about rhythmically.

She continued out-of-doors during November with apparently no harmful effects at all. On November 22, 1929, the thermometer registered 40° Fahrenheit (4° Centigrade), that is, only eight degrees above freezing according to the Fahrenheit scale. On November 30, 1929, Penserosa was outdoors during the day when the thermometer registered 18° Fahrenheit, a temperature below freezing. Her coat of hair



became heavier and more luxuriant as the winter progressed. She did not suffer from the cold as her breath steamed in the sharp morning air, while she played in the outdoor cage. Allegra, the chimpanzee, however, shivered and remained in the indoor cage most of the time.

Snow was falling lightly on the floor and bench in the outdoor cage on the morning of December 3, 1929. The cage door was slid open and out romped both gorilla and chimpanzee. At first they looked about them inquiringly for a moment or two as the snow fell around them. They tried to catch a few snowflakes in their hands, and then picked up some snow from the floor of the cage, lifted it to their mouths and ate it. Like little children they seemed to enjoy their first snowstorm. Later the gorilla would pick up small pieces of ice and crunch them between her teeth (Figs. 24, 25, 26, 27).

Penserosa continued to enjoy being out of doors each day throughout January, February, March, April and May—one whole year, with no bad effects. She did not contract a cold during this time and remained in good condition. This is perhaps the first time that a gorilla has been kept out of doors during the day for an entire year in the North Temperate zone. In this case it would appear that cold weather does not have a harmful effect upon a young female gorilla. It seems probable that these anthropoid apes are more liable to succumb to respiratory infectious diseases on account of a low degree of resistance when brought into contact with infected human beings.

From about the middle of February to the end of March in 1930 Penserosa did not eat very well and appeared to be fretful and irritable. She did not gain in weight during this period. It was with considerable difficulty that her mouth was examined. The gums behind the milk teeth were swollen, tender, reddened, and painful. Her first permanent molar teeth, which correspond to the six-year molar in man, were in process of erupting through the gums. This condition was the cause of her irritability. All four first permanent molars were visible during the last week of March, 1930. She now had twenty-four teeth, of which twenty were temporary milk teeth, and four were permanent molars. Her age at this time was estimated as

about three years. The chimpanzee's permanent molars appeared during this same period of time.

When in good humor she manifests her pleasure by slapping her abdomen with her hands or by rolling over and over on the floor. Frequently she builds a simple circular nest of straw and as a diversion rides about on the back of the chimpanzee.

From a distance, one is impressed by the bulk of her body and strong, broad shoulders. The head, with its beetling brow protruding over deep-set light brown eyes and large round open nostrils, is set close to her body. Two prominent vertical wrinkles in the middle of her forehead, deep semi-circular wrinkles below her eyes and firm lips add to her old, serious appearance. The texture of the black facial skin is soft. The outer portion of the lips is smooth and black while the inner part of the mouth is pink.

She lies on her back and spins herself around very rapidly by pushing against the sides of the cage, and dances about the floor beating her chest with her hands in a slow and even tempo, which would seem to indicate a sense of rhythm.

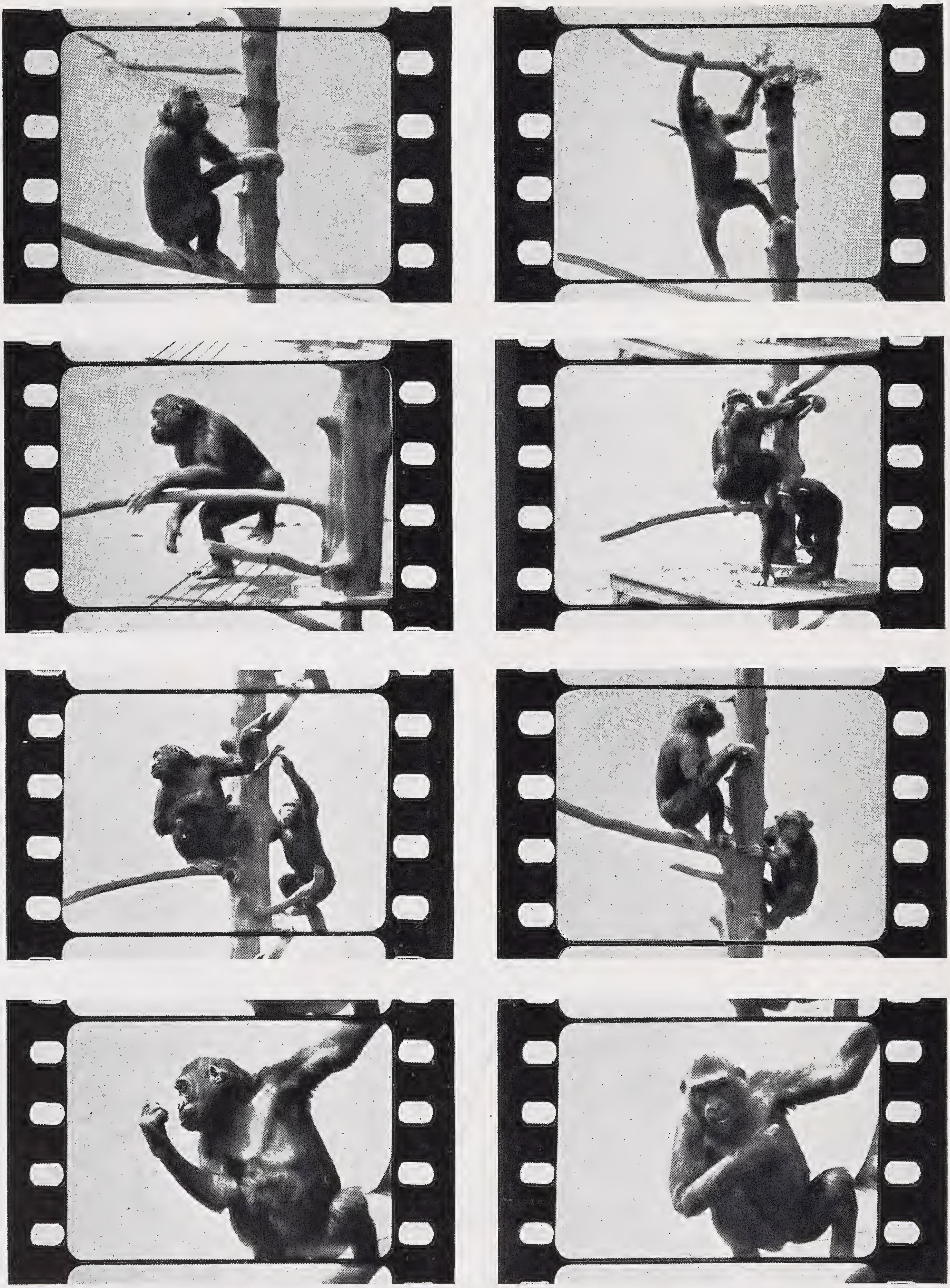
Hair Coat

On general examination the smooth hair coat of Penserosa appears to be solid black with the exception of three small areas of white, two white patches on the cheeks in front of the ears, and an area of white surrounding the anal region. The hair covering the crown of the head is close cropped and stands out in a pompadour fashion. It consists of a mixture of rufous (red), black, white and grizzled hairs, giving the crown a variegated appearance. On closely examining some of the individual hairs from this region four color types were found: 1. Black. 2. Black and white banded. 3. Rufous with black tips. 4. White.

Individual hairs from the body were mostly solid black although a few scattered individual black and white hairs were also found. A considerable number of black and white banded hairs were found upon the outer thighs which on general examination present a grizzled appearance.

Her chest is partially covered with a sparse coat of hair. The skin is dark grayish in color while the skin of the body has a light flesh color which can be seen as the hair is pushed back.

With the exception of a slight, acute enlargement in the softer tissues of the right wrist (radiographs revealed the bones of the wrist as apparently normal), Penserosa at present appears to be in good physical condition. Her weight on March 18, 1930, was forty-two and three-quarter pounds (19.4 kg.) while the weight of Allegra was thirty-one and one-half pounds (14.31 kg.), Penserosa being heavier by eleven pounds. The greater part of each day was spent out of doors during the summer and fall of 1930. She continued to remain out of doors throughout the winter of 1930 and 1931, remaining free from colds and steadily gaining in weight. Her weight reached fifty-eight pounds (26.3 kg.) on April 16, 1931, while the chimpanzee was forty-one pounds (18.6 kg.).



The series of poses of the gorilla and the chimpanzee on this page, and also those on pages 96 to 102, are shown to illustrate spontaneous attitudes during activity as recorded by the camera.

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BULLETIN
NEW YORK ZOOLOGICAL SOCIETY

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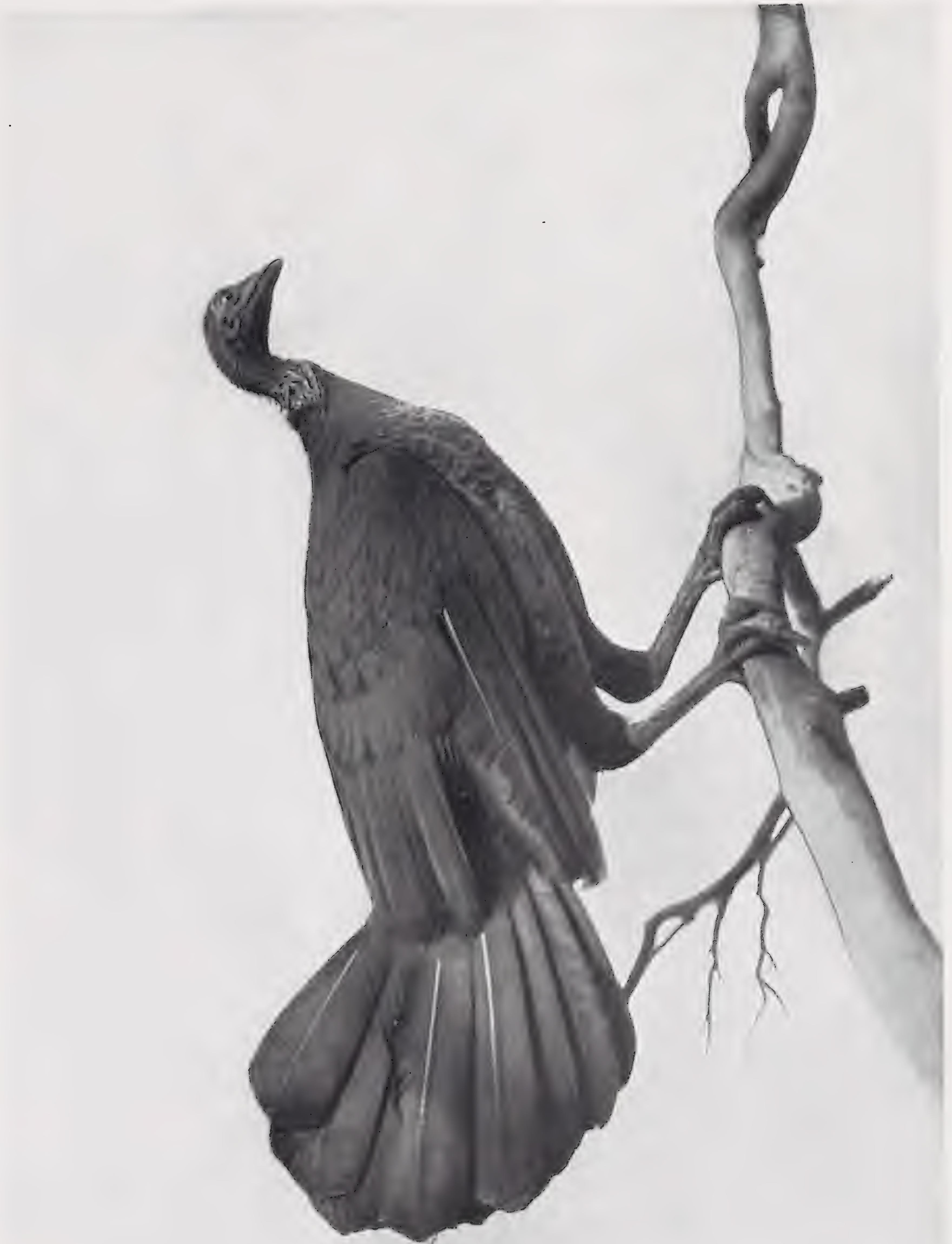

Australian Brush-turkey, photographed in the Zoological Park. The Brush-turkey includes several species found in New Guinea and the nearby islands, as well as the Australian bird. The latter is distinguished by the large yellow neck-wattle of the male.

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Avian Mound Builders and Their Mounds

Notes on the habits of the Australian Brush-turkeys, by Charles Barrett, with a brief introduction by Lee S. Crandall, concerning specimens of the family Megapodiidae that have been exhibited in the Zoological Park.

Illustrations from photographs made in the Zoological Park, and from field photographs by Mr. Barrett and other naturalists.

INTRODUCTION

THE mound builders, or megapodes, are a fairly large family of birds, about forty forms, of seven genera, having been described. They have a wide distribution in Australia and the islands to the north of the "island continent," including New Guinea and the Solomons, extending west to the Nicobars and north to the Philippines. Their affinities are undoubtedly with the gallinaceous or fowl-like birds, and their most obvious physical characteristic is the proportionately great size and power of the feet and legs. This peculiarity is correlated with the mound building habit, for it is with these implements that the birds gather the huge heaps of debris which serve as incubators for the eggs.

Only three species of this interesting family have been exhibited in the Zoological Park. These are the mallee fowl or ocellated megapode, the scrub-fowl and the brush-turkey, all described by Mr. Barrett in the following article.

The ocellated megapode (*Leipoa ocellata*) is found in the southern portions of Australia, two subspecies being recognized. In its native land, it is known variously as lowan, mallee fowl, mallee hen, native pheasant, etc. Never a common bird in captivity, this megapode is now seldom seen in collections and rightly, for there seems no doubt that it is rapidly becoming scarce. Moreover, it does not seem to thrive particularly well in confinement, at least in the climate of New York, and none of our specimens has lived for more than a few years. It is a bird of dull and lethargic temperament, disinclined to exercise, which may account, to some degree for our lack of success with it.

The scrub fowls (*Megapodius*), on the other hand, are alert and active little creatures, much like perky domestic fowl, with out-sized feet. Mr. Barrett's bird is *M. reinwardt tumulus,* found in the Northern Territory and northern Queensland, Australia. Some thirteen other subspecies of *M. reinwardt* are listed, from New Guinea and neighboring islands. Our representatives of the genus were Reinwardt's scrub-fowl (*M. reinwardt reinwardt*), from the mainland of New Guinea. During the Zoological Society's expedition to that island, in 1928, I saw many nest mounds of *Megapodius,* and several times surprised the owners close at hand. Although they can run with speed, they usually took flight, flapping through the heavy bush on clumsy wings. In spite of their abundance, however, I was unable to secure living specimens. The birds exhibited here were obtained from dealers.

The brush-turkey (*Alectura lathami lathami*) of Queensland and New South Wales, was once a fairly common bird in capitivity but the re-

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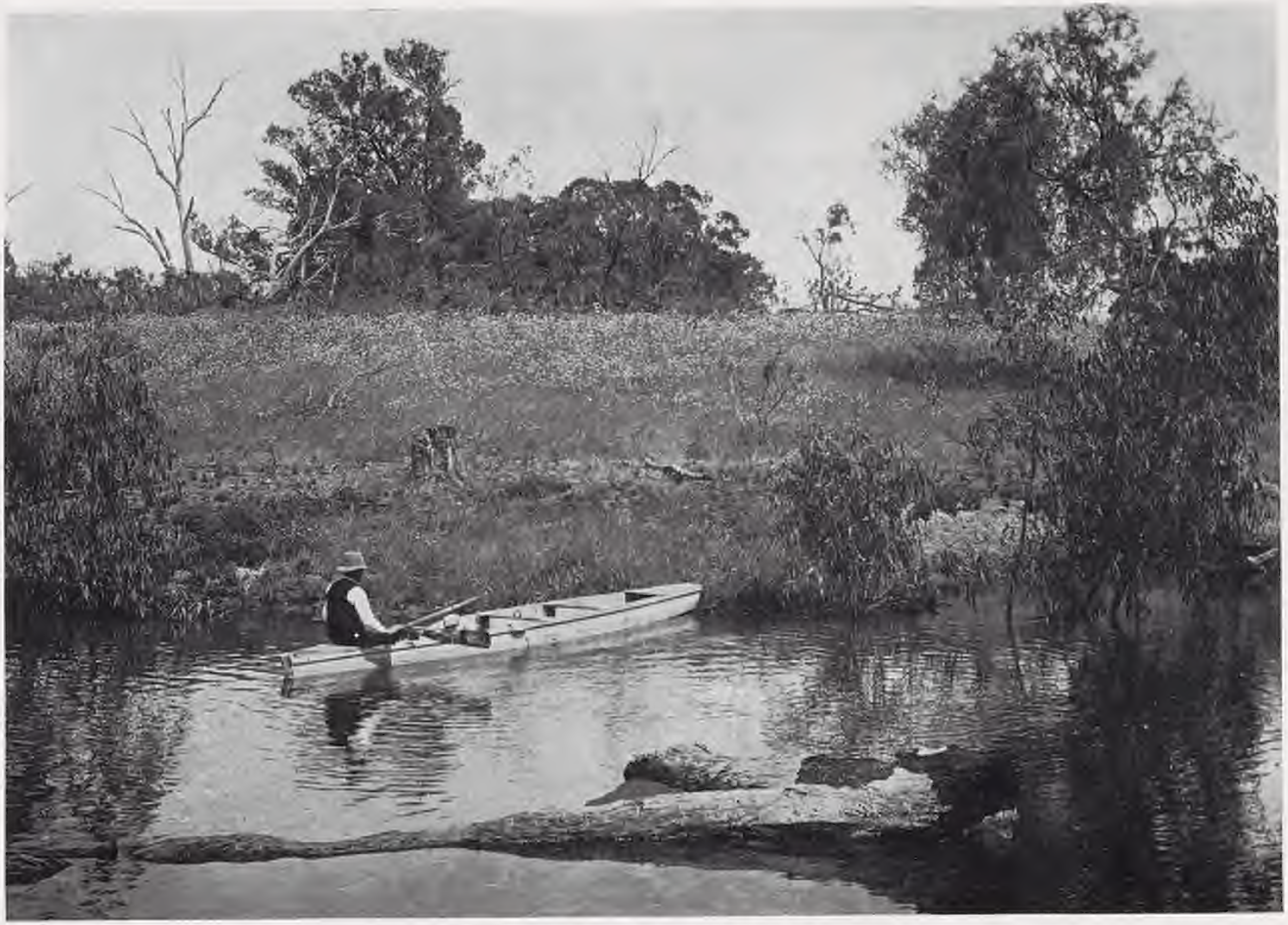


"Isle of the dead." The lonely burial place of an extinct Australian aboriginal tribe. This isle is really a great, flattened sand dune, with the river flowing past one side and a creek round the other. Here the blacks buried their dead in the sand, and hundreds have been interred. Some of the graves are marked by rotting logs, piled there by men who long ago were themselves buried on the Isle. In the spring and early summer this primeval cemetery is fairly alight with masses of gayly colored wild flowers. Photograph by Charles Barrett.

strictive laws now in force in Australia have placed it among the rarities. Fortunately, it is extremely hardy—two specimens now in our collection have been here since 1922.

Perhaps because of the propensity of the males for killing their mates, we never have been successful in breeding the brush-turkey, although this has been accomplished on several occasions in Europe. However, our birds are constantly building mounds and almost daily may be seen busily adding to the heaps of sand, leaves and twigs in their separate enclosures.

In 1918, a male brush-turkey escaped from his run in the Zoological Park and disappeared. Nothing was heard of him for several days, when we learned that the grounds force was greatly incensed over a huge heap of leaves which had been erected in a tangle of underbrush near the Jungle Walk. Small boys were suspected of this sacrilege but constant watching had failed to disclose the culprits.

Our truant brush-turkey came instantly to mind and we went at once to the scene of the reported vandalism. A loud rustling and scratching under the rhododendrons, which ceased as we drew near guided us to the spot. We found a circular mound of leaves, sticks and rubbish which measured, roughly, twelve feet across and three feet high. For many yards around, the earth had been scraped quite clean. Too clean, it seemed, to be the work of a large and clumsy bird. But we had only to wait silently for a few moments, when a dark form emerged stealthily from the shadows and revealed itself as our lost brush-turkey. Immediately he went to work, his back toward the mound, throwing clouds of leaves and debris behind him, as he progressed, crab-fashion, toward his objective. There was a small brook to cross but this was no real obstacle. Sturdily the bird scraped his rubbish into the water, then scraped it out again on the homeward side.

For some weeks the mound grew and took shape, and many interested persons had opportunity to watch the bird at work. Then one morning, we found him dead, the victim of the type of visitor against whom we are always on guard, though not always with success.

◆

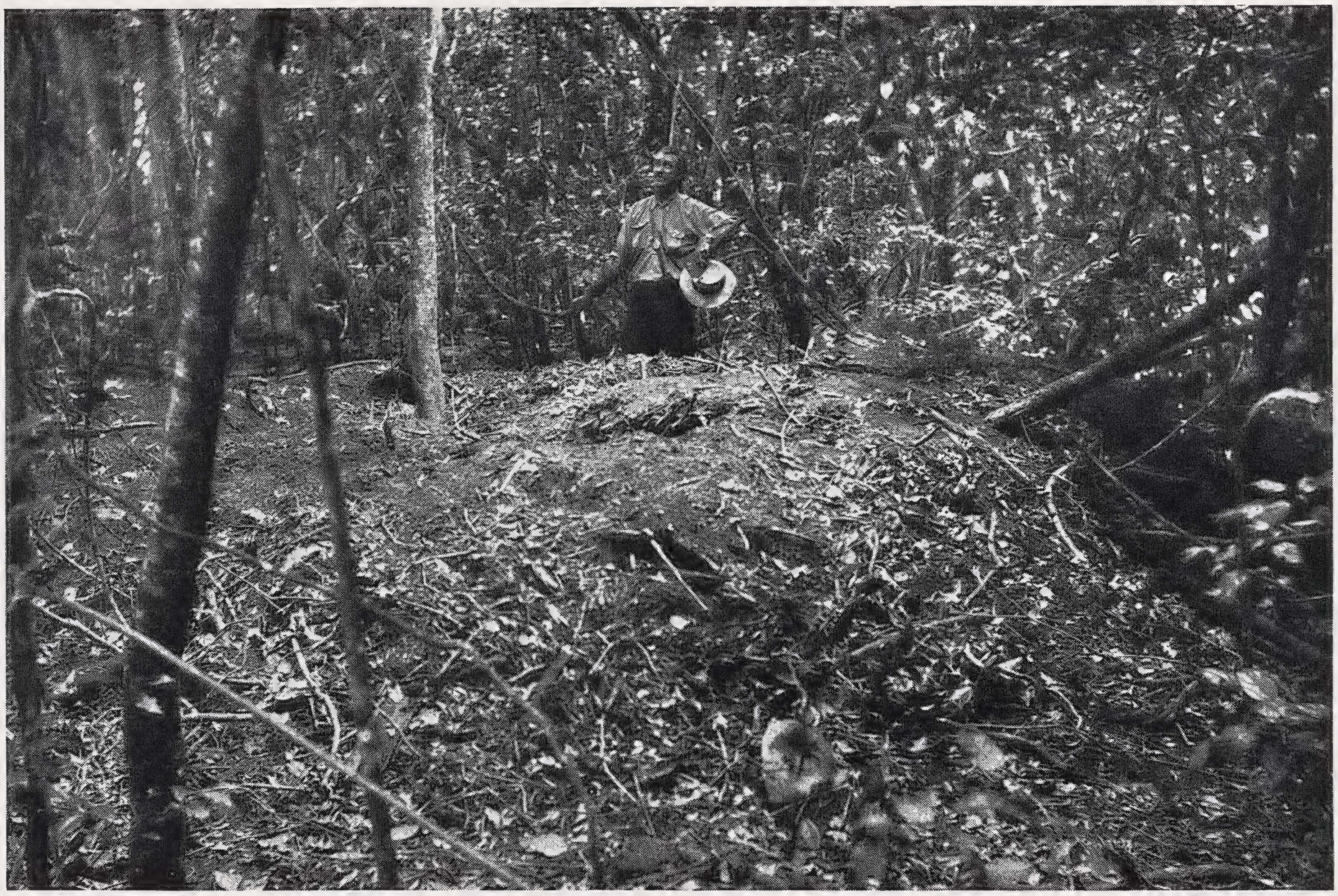
THE nest-structures of the mound-building birds of the Australasian Region, are not unlike miniatures of the ancient man-made mounds in America, works of the prehistoric Indians where skeletal remains and stone implements are found in these huge artificial hillocks scattered through Ohio, Illinois and other areas in the United States.

These marvellous birds, in their nesting habits, reveal kinship with reptiles. A reptilian characteristic has survived through the ages in the Megapodiidae. They do not sit upon their eggs, but deposit them in big mounds of earth and sand, sticks, twigs, and rotting vegetation. The "hot-bed" in the mound is an incubator: heat produced by decomposition of the vegetable matter hatches the eggs. The chicks are most precocious; they are born feathered, work their way to the surface of the nest-mound, and are able both to run and to fly when only a day old.

None of my birdland memories is more deeply etched than that of the first glimpse of a mound-builder in its haunts. Twenty years ago, in the victorian country, I met with the Lowan, and excavated one of the natural incubators, which are as remarkable, in their way, as the Bower-builders' play-halls. Since then, I have enjoyed many outings among the Lowans, and the other mound-makers that live in sub-tropical scrubs and the jungles of North Queensland.

The small family Megapodiidae is almost confined to the Australasian Region, and, as Newton observes in his "Dictionary of Birds," is highly characteristic of some parts of it: this applies mainly to the peculiar dry areas of south-eastern and south-western Australia, which we term Mallee, from the fact that the principal vegetation consists of dwarf Eucalypts or gum trees (the dominant form over great areas is *Eucalyptus dumosa*). Some species of Megapodes actually bury their eggs in the ground (a distinctly reptilian trait); others are more advanced, being mound-builders. Morphologically, the Megapodes are very primitive, possibly lower than any other family of birds.

More than four centuries ago, the remarkable habits of a mound-building bird were observed, in the Philippines, by Antonio Pigafetta, a survivor of Magellan's famous voyage. Under date,



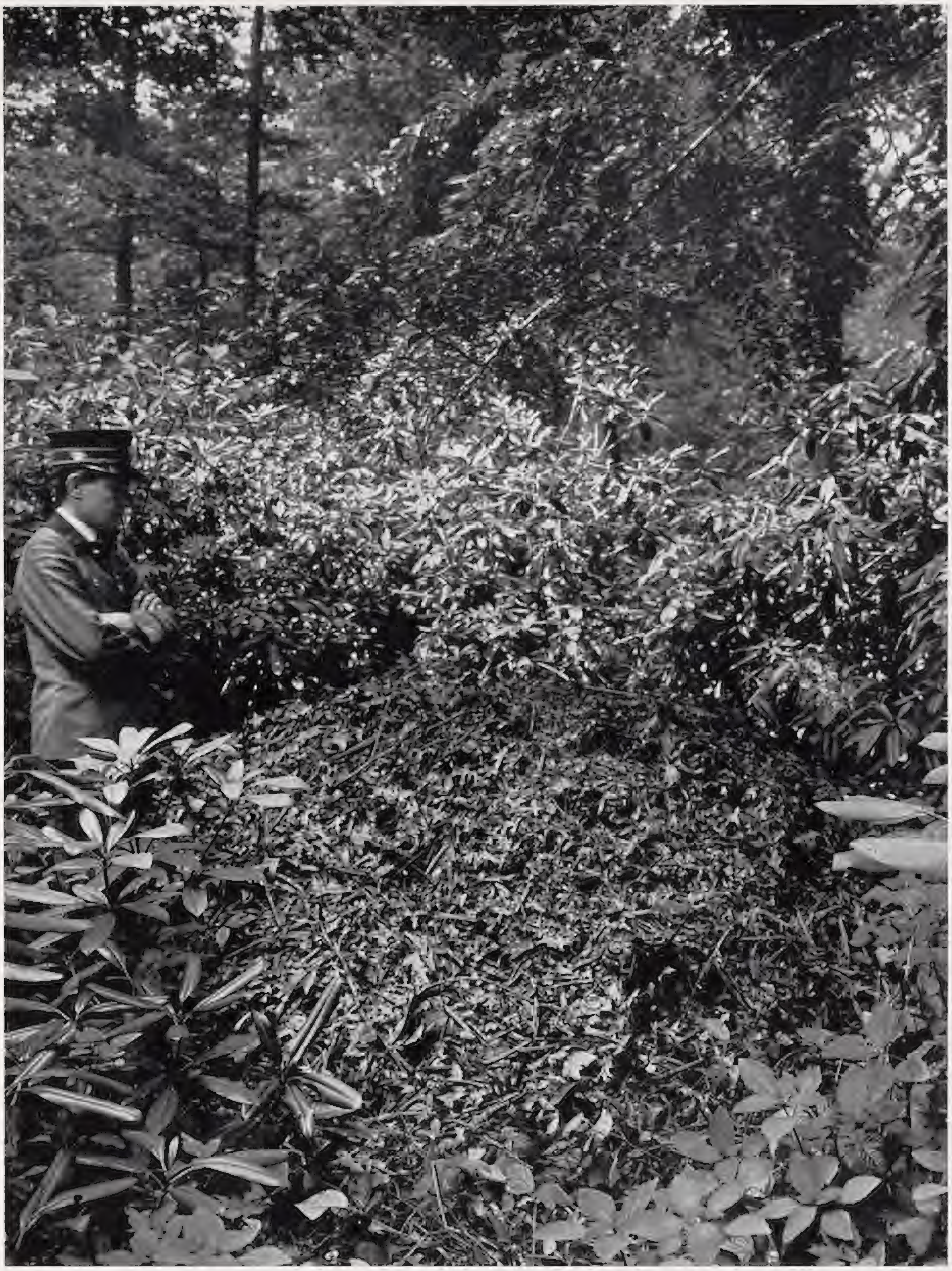
The nesting mound of a Scrub-fowl, *Megapodius reinwardt*, in the jungle. These mounds are used year after year and thus increase to large proportions. the birds scraping out the egg-chamber and adding new material at each nesting period. In a mound seven feet in diameter and three and one-half feet high, there were about three cartloads of earth, leaves and sticks. The heat generated in the egg chamber is as high as 95 degrees. Photograph by Charles Barrett.

April, 1521, Pigafetta gave in his journal the earliest record of an avian mound-maker. He describes the bird as being about the size of a fowl, and states that it lays, in the sand, eggs as big as those of a duck, which are hatched by the heat of the sun. There are other very early records; and, in 1703, in his observations on Birds of the Philippines, Petiver communicated to the Royal Society of London an account of the Megapode of Luzon. The species that inhabit Amboina and Celebes, respectively, were described in 1726, by Valentyn. But the learned men of Europe were skeptical; accounts of the Megapodes' strange nest-habits, from that given by Pigafetta to Valentyn's description in his work on the East Indies, were discredited, as merely marvels, by naturalists.

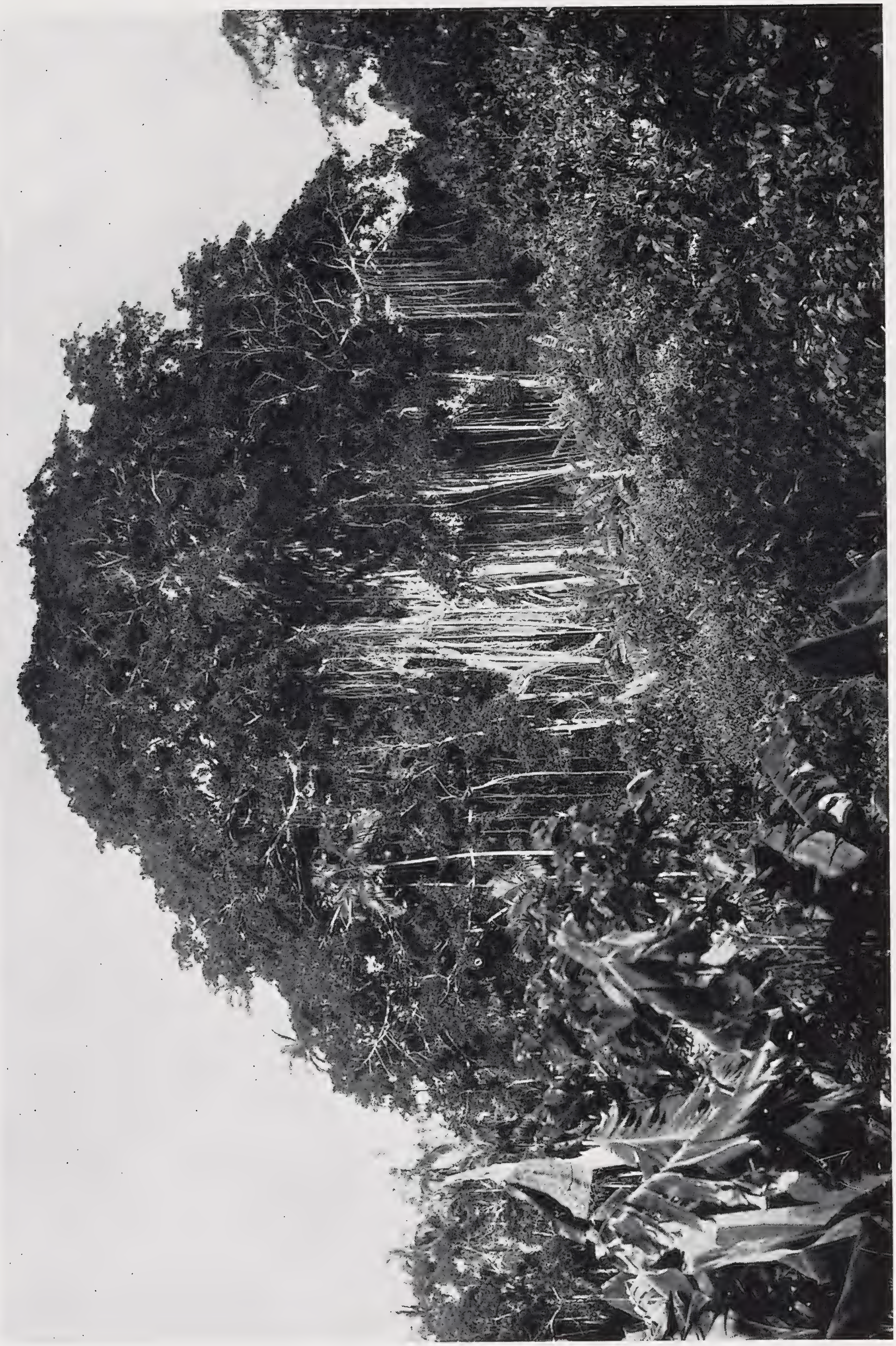
It was an Australian mound-builder, the brush-turkey (*Alectura lathami*), which won for the Megapode family scientific recognition. It was originally described by the naturalist whose name it bears, Latham, in 1821; but he called it the "New Holland Vulture." Later, he discovered his error, in classing among the carrion-eaters a bird of Galline character.

We have, in Australia, only one species; in New Guinea and other islands there are six or more different Brush-turkeys. Our form is the largest. About the size of a domestic hen-turkey, it is of a general sooty-brown to blackish-brown color, the under surface being brownish-gray with white edging to some of the feathers. The nearly bare head and neck are pinkish-red and this brightly colored skin, which is beset with fine bristles, contrasts with a large bright yellow wattle on the breast. This is a portrait of the male; the female is similarly colored, but lacks the ornamental wattle. The birds are really henlike in appearance; usually they carry the tail partly folded, and upright.

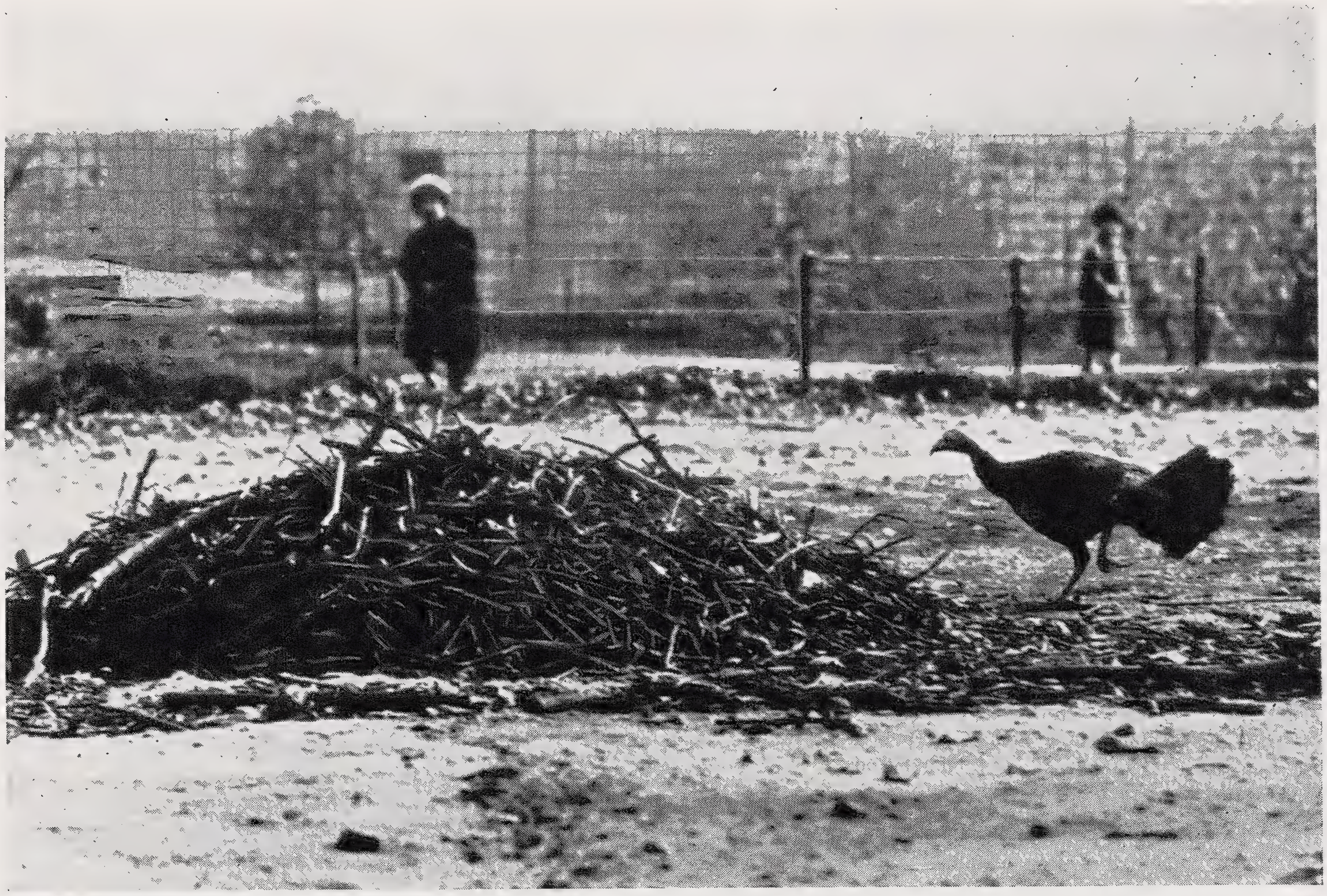
The brush-turkey ranges from Cape York, North Queensland, down into eastern New South Wales, and is plentiful enough in many localities. It is one of the most remarkable creatures of the palm scrubs of the eastern coastal ranges, and also occurs inland, in places where the conditions are suited to its needs. It is known commonly as brush-turkey, but often is called the Wattled Talegallus. One has glimpses of it running rapidly through the un-



Mound constructed by a Brush-turkey in the forest along the Jungle Walk in the Zoological Park. The bird escaped from his quarters, and for several days remained entirely concealed, although the Park was hunted over with great care. Subsequently a report was sent to the office that some person had been heaping leaves into a pile in Beaver Valley, which, upon investigation, proved to be the work of the missing Brush-turkey. The heap was about twelve feet in diameter and three feet in height, and the ground around the edge of the mound was scraped entirely clean of leaves and debris; an excellent illustration of the speed and perseverance of this strange bird.



The side of a Scrub-fowl's nest in Queensland in the heart of the Australian jungle. This is the southern limit of the range of the Scrub-fowl, where now banana plantations are encroaching on its haunts. The banyan (Ficus) tree in the photograph is one of the largest known in Queensland, and it is frequented by hordes of fruit bats, the flying-fox, which finds shelter in the dense foliage of the upper branches. Photograph by Charles Barrett.



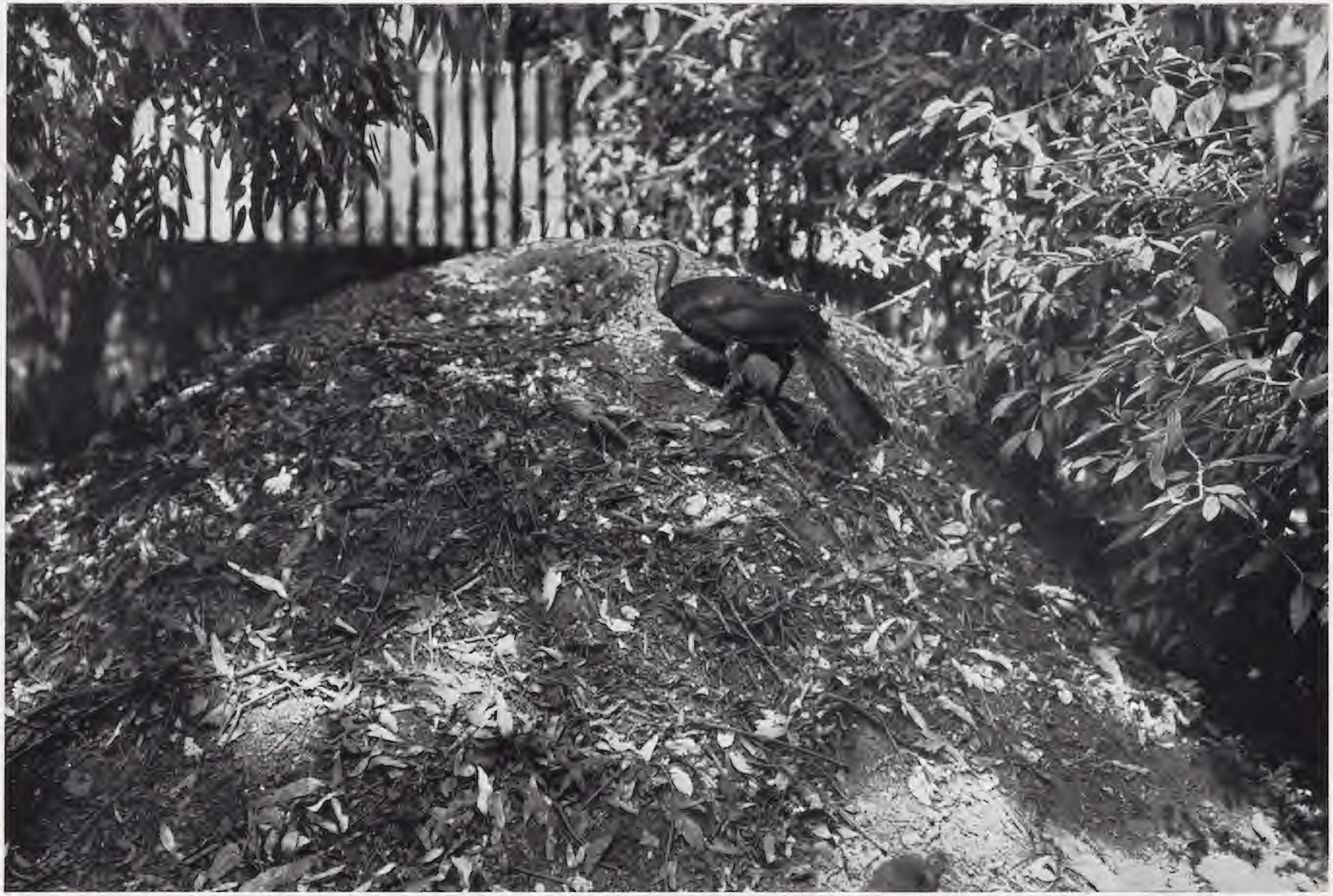
A Brush-turkey, called by Gould the Wattled Talegallus, in the Zoological Park. Often wild animals adapt themselves readily to confinement and with encouragement manifest the instincts common among them, particularly that of breeding. The perpetuation of the species is the most irresistible impulse, and the mass of sticks and vegetation, a rough imitation of the nesting mound which was placed in the yard, was an invitation which the occupant could not ignore. Photograph by Lee S. Crandall.

dergrowth, dodging easily the thorned stems of the lawyer-vine (*Calamus*), and other obstructions to the progress of an intruder in its haunts. Its carriage facilitates quick movement where the ground is cumbered with growth and rotting logs, snake-like roots and stems, and crowding ferns. The body is carried with a forward dip, while the bird is travelling through the scrub.

Immense mounds are raised by brush-turkeys, usually in the midst of dense scrub or in forest glens, frequently on the slope of a hill. They are more or less circular and dome-shaped. Size varies, of course, but a fairly typical mound would measure, at the base, about thirty-six feet in circumference, and about three feet in height. But larger mounds are not rare: I have seen one six feet in height and nearly fifteen feet in diameter. The pyramidal form is usual, not invariable; nor is a steep slope always chosen; mounds on fairly level spots often are met with. But the birds have a distinct preference for secluded home-sites.

Long before egg-laying time, the birds are busy preparing collecting material for the nest-mound. They work industriously, clearing a space perhaps forty or fifty yards in diameter, of debris—fallen twigs and leaves from the jungle trees and bushes: the ground may be left almost bare for many yards around the great heap, which gradually rises. Brush-turkeys are accomplished scratchers, and seem to enjoy their mound-building activities. I have watched them at work. Some observers state that each mound is raised by one pair only; others, that several birds assist in its construction. It is not unusual to see one male turkey joyously scratching and scraping on the mound; also I have observed two or three birds thus employed. The late Mr. D. Le Souef, Director of Melbourne Zoological Gardens, closely watched brush-turkeys, both in the wilds and in captivity. His observations indicate that the male makes the mound unaided, and jealously keeps the hen birds away, should they attempt to scratch holes in the heap before he considers it to be ready for eggs. "He beats them off unmercifully."

Brush-turkeys have been reared at the Melbourne Gardens. From the huge mound in the Talegallus enclosure, seventeen young were



A Brush-turkey in the Zoological Gardens, Melbourne. This photograph illustrates very graphically the magnitude of the labor performed by these birds in constructing their nesting mounds. When the size of the mound is compared with that of the bird, the performance seems almost incredible. In the wilderness these nesting sites gradually assume enormous proportions, as they are used year after year and frequently by several birds. This mass of vegetation ultimately becomes a rich compost heap that encourages the growth of shrubs and trees, and in time become so thickly filled with living roots as to destroy its use as an incubator. The birds, unable to cope with this condition, then seek another site and again construct their mound. Photograph by the late D. Le Souef.

hatched, one season; they made their own way to the surface, and all but one was reared to maturity. During another year, no fewer than fifty-six eggs were deposited in the mound: there were several birds in the enclosure. This clutch was a failure, through lack of sufficient vegetation in the mound to generate the heat required for hatching. The newly-emerged chick is of a dark-brown color. It does not chip its way out of the shell, which is brittle at the stage when hatching is imminent; but bursts the egg into small pieces by its "struggle for freedom." The day-old chick is nimble-footed and partly feathered, its wings being developed sufficiently for a little flight to some lower branch of a tree near the mound, should danger threaten.

When only one pair uses a mound the complement of eggs will be from about twelve to sixteen; while a community mound may contain several dozen. A hen, when the urge to lay prompts her, scratches a hole in the mound, less than a foot in depth and near the summit, usually. After the laying, she leaves, and the hole is filled in by the male with debris, which he tramples down. Eggs in all stages may be found in the same mound; they are placed in a perpendicular position, and, roughly, in tiers.

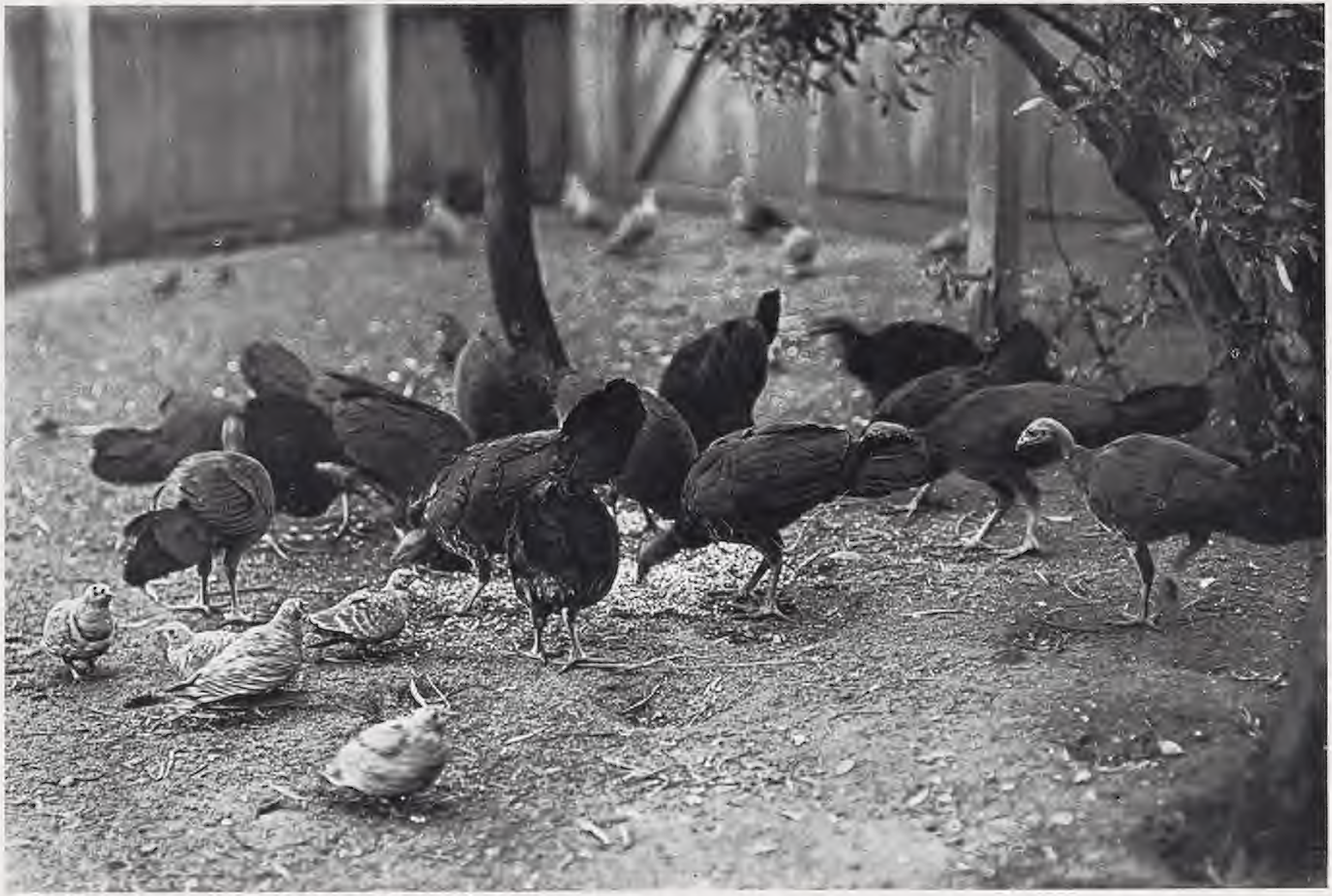
The parent birds frequently are seen at the mound, and perhaps are watchers during the whole period of incubation, which is lengthy, since fresh eggs may form the final, central, layer or circle, while those first laid at one side of the incubator, are on the point of hatching. Whether the females are in constant attendance, when hatching is likely, and frequently uncover and cover the eggs again, with the object of helping any young that may have appeared, I do not know. That such is the case, some of the aborigines assured Gould; but others declared that the young received no assistance.

Decayed leaves, etc., mingled with fine debris, form the central part of a mound; coarser layers follow, and, finally the builders add bushels of fresh material—twigs and leaves, and sticks of assorted sizes.

Brush-turkeys have many human enemies: the birds are shot for food, by settlers, in some districts, and their mounds are robbed, since the large white eggs (elliptical in shape, with coarse textured shell) are good eating. Among natural enemies are the great lizards popularly called "goannas". Our monitors are of formidable size, one species attaining a length of over 9 feet. They dig into the mounds with their large and strong claws, and devour any eggs discovered.

The scrub or jungle-fowl (*Megapodius reinwardti*), the second of our trio of mound-raisers, was named *M. tumulus* by Gould. Besides the Northern Territory of Australia and North Queensland, its range includes New Guinea, and some of the lesser islands, as Aru, Banda and Flores, and Lombok. From Wallace's Line to the tropical north of Australia, is an extended distribution. My first acquaintance with the scrub-fowl was made on an isle of romance which bears the prosaic name of Dunk! I was staying with my old friend, the late Mr. E. J. Banfield, whose books, "Confessions of a Beachcomber", "My Tropic Isle", and "Tropic Days", have made the lovable man and his island home familiar to readers in many countries. No one has written such an intimate account of the jungle-fowl as that contained in The Beachcomber's earlier pages. He has written delightfully, too, of this, a favorite species, in letters to me. Sometimes on the island, together, we watched his bird friends in the jungle, or the bungalow garden. They were always entertaining. And mounds were not far distant. Often, in the evening, as the birds were going to roost, we heard their loud, chuckling notes.

The scrub-fowl, also called "Scrub-hen," has dark chestnut-brown plumage, dark grey on the under surface, a brown crest, and reddish-brown feet. The sexes are similar in appearance. They are comical birds, and, with due encouragement, become confiding. I quote from one of Mr. Banfield's letters: "Since you left the island those big blue and green butterflies (*Papilio ulysses*) have been plentiful, and the scrub-fowls so cheeky that the pups hunt them out of the garden. I saw five scrub-fowls among the orange trees the other day, in very holiday humor, playing circus or merry-go-round, or some other circumlocutory pastime. With outspread wings sweeping the ground, they danced with zest while cackling as if the whole isle belonged to them. The swamp-pheasants (Pheasant-coucals) are wonderfully tame and the cheeky Honeyeater alighted on the head of the couch while I was reading, the other afternoon."



A flock of Brush-turkeys, with a number of sand grouse, in captivity. At the first glance the birds could be mistaken for the domestic turkey of our own country, the one element lacking to make the illusion convincing, a strutting gobbler. This species is not so shy as several of the others and this seems to be borne out by the placidity of the behavior of the birds in this photograph. One species of the brush-turkey is found in Australia, but there are several others in New Guinea and the adjacent islands. The family Megapodiidae, to which the brush-turkey belongs, ranges through the Australasian Region, and occurs also in the Philippines, Borneo and the Nicobar Islands, localities that are not within this area. Photograph by the late D. Le Souef.

On Dunk Island, there is an old mound beneath the branches of a giant fig tree (*Ficus*) and near the edge of the beach, where vegetation begins. It has seen many seasons, and when I saw it was overgrown with little pioneer jungle plants. Commonly, mounds are formed within a few hundred yards of the tropic beach, but also far from the sea. At Byfield, for example, a district about nine miles inland, we found the scrub-fowl at home, and plentiful, in "brush" on the hills and along creeks that flow through this Queensland plateau to the sea. Byfield, the southern limit of the scrub-fowl's range, is a banana-growing district with rich soil on the slopes and summits of its hills, so that the jungle is doomed. Farms on the hillsides have deprived *Megapodius* and other birds of much territory. The mean annual rainfall of Byfield is seventy inches.

We located several mounds. One, situated on a mountain plateau, measured 25 feet in diameter and eight feet in height. Hidden in dense scrub, it was steep-sided and rather small at the top. Another mound measured forty feet in circumference and nearly ten feet in height. Here we disturbed a raider: a monitor lizard emerged from the hollow in the mound, where it had been delving for eggs.

The scrub-fowl is a mighty builder, using "cartloads" of dark, sandy soil mixed with decaying vegetation, twigs, sticks, etc. Sand and shells are the principal building materials when the egg-mound is near the seashore. These rounded structures—sometimes conical—dwarf those raised by the brush-turkey and the Lowan. The Megapode mound measured by Gould's collector, Gilbert, in a far northern locality, was 150 feet in circumference and fifteen feet in height, and contained, it has been estimated, almost 9,000 cubic feet of soil and debris.

While the mallee-fowl and the brush turkey both open up their mounds for the purpose of egg-laying, the megapode burrows into the tumulus to deposit each egg. The holes may be over six feet in depth, and one egg only is laid in each, at least as a rule. After the laying, the hole is filled up, soil being scratched into it lightly by the bird with its powerful feet; the work is done expeditiously, for these jungle dwellers are master scratchers.

The large eggs, of long ellipse shape and pinkish or yellowish-buff color, are hatched by the heat which fermentation of the mass produces at a depth of several feet. The temperature is about 94 deg. The complement varies, the average being eight or ten eggs. Almost invariably, only a pair of birds is observed at a mound at the same time. The eggs, apparently, are deposited during the night, and at fairly long intervals—several days. Occasionally, eggs are deposited in the open; at least, I have seen one lying in a "cave" among the buttress roots of a tall jungle tree. The megapode of Savo, one of the Solomon Islands, dispenses with the mound, instead burrowing into the sand. Into a main burrow, side ones lead, an egg being deposited in each. All the burrows are filled in after the laying.

Megapode mounds are used season after season, and added to annually, until, from small hillocks they have grown to huge proportions.

The third of our trio of mound-builders, birds that are industrious workers but dispense with the duty of incubation, is the Lowan or mallee-hen (*Leipoa ocellata*), often termed "native pheasant." None of the megapodes has been more intensively studied than the Lowan, which inhabits dry, scrub-covered country in the southern half of Australia, ranging from Southwestern New South Wales, through north-western Victoria, southern parts of South Australia, and the western state—an extensive distribution. The bird is closely associated with mallee (dwarf species of gum-tree—Eucalyptus), and, deprived of its shelter and seclusion, soon disappears from age-old haunts of its species.

Settlement has encroached on vast tracts of the Lowan's territory, and steadily the advance continues. In Victoria an area of over 30,000 acres of Mallee country has been reserved, as sanctuary for wild life and the mallee flora. Ere another half century has passed, the mallee-fowl or hen may be nearing extinction in Victoria, outside reserves. There are still extensive tracts of untamed Mallee, but the process of converting our northwestern wilderness into wheatfields continues, and the native fauna receives scant consideration when its haunts are coveted for cultivation. We are fortunate to save an area here and there, wherein to conserve the country's original animal inhabitants. There is not a wild aborigine left now in the

Mound of the Scrub or Brush-turkey in Queensland. In the lightest timbered country with belts of thin scrub, the brush-turkey makes its mound, and here also the wallabies abound. The nesting mounds in this locality, as described by Le Souef, were three or four feet high and seven feet in diameter. The birds do not start to build up their nests until the vegetation is sufficiently moist to generate the heat necessary for the incubation of the eggs. Photograph by the late D. Le Souef.

whole state; only a handful of blacks on stations, none of whom has experienced the primitive life of a Stone Age people.

As a member of the Wonga Park Committee of Management, I have visited the reservation several times, and traversed it in all directions, and have camped on its lakes, which are dry, grass-grown hollows, excepting for a year or two after successive seasons of ample rainfall. The mallee is a land of little rain, and our Park's small lakes are linked by a winding creek with big Lake Albacutya and Lake Hindmarsh. Albacutya may remain dry for years, but while it is empty, the Park creek and lakes also are waterless. But we have drinking-places for the cockatoos, parrots, and other species—troughs filled from wells, and the Park is a paradise for the bird lover, especially in nesting time. It is the only mallee reservation in Victoria, and should be four times as large to ensure the future of the Lowan and some other birds peculiar to the dry north-western region. The Outlet Creek, remnant of a river, is Wonga Park's central feature, flowing—when it *does* flow—from lake to lake, between gum-tree lined banks to Pine Plains, one of the oldest stations (ranches) in Victoria. Much of the area consists of sand-hills, covered in darf Eucalypts and other typical mallee vegetation. There are high and low ridges covered in Murray pines (*Callitris*), and wide valleys, alight with wildflowers in the Spring and early Summer time. One depression, a water-mirror for the sky at intervals of years, we call Golden Lake, because a beautiful-flowered acacia grows freely on its borders, bushes all golden with bloom in September.

About ten square miles of the Park area consists of typical Mallee-fowl country, and some nest-mounds have been located there: we hope that it contains many. Occasionally I see Lowans in the Park, but observations on this wonder bird were made chiefly in other districts, before settlement had tamed the wilderness of scrub and sand and pine-ridges.

Pine Plains homestead has been my headquarters during several camera-hunting expeditions among creatures of the Mallee; and for half a century this historic station has been noted among naturalists. Hollows in dead gum trees that dot the home-paddocks are nesting-places of parrots and cockatoos. Wonga Park is the only area in Victoria now, where the lovely Regent Parrot (*Polytelis anthopeplus*) still rears broods every season. Wonga, also, is one of the very few nesting haunts, in the State, of the pink cockatoo (*Cacatua leadbeateri*). When any naturalist from America visits Victoria, I propose a trip to our Mallee reservation.

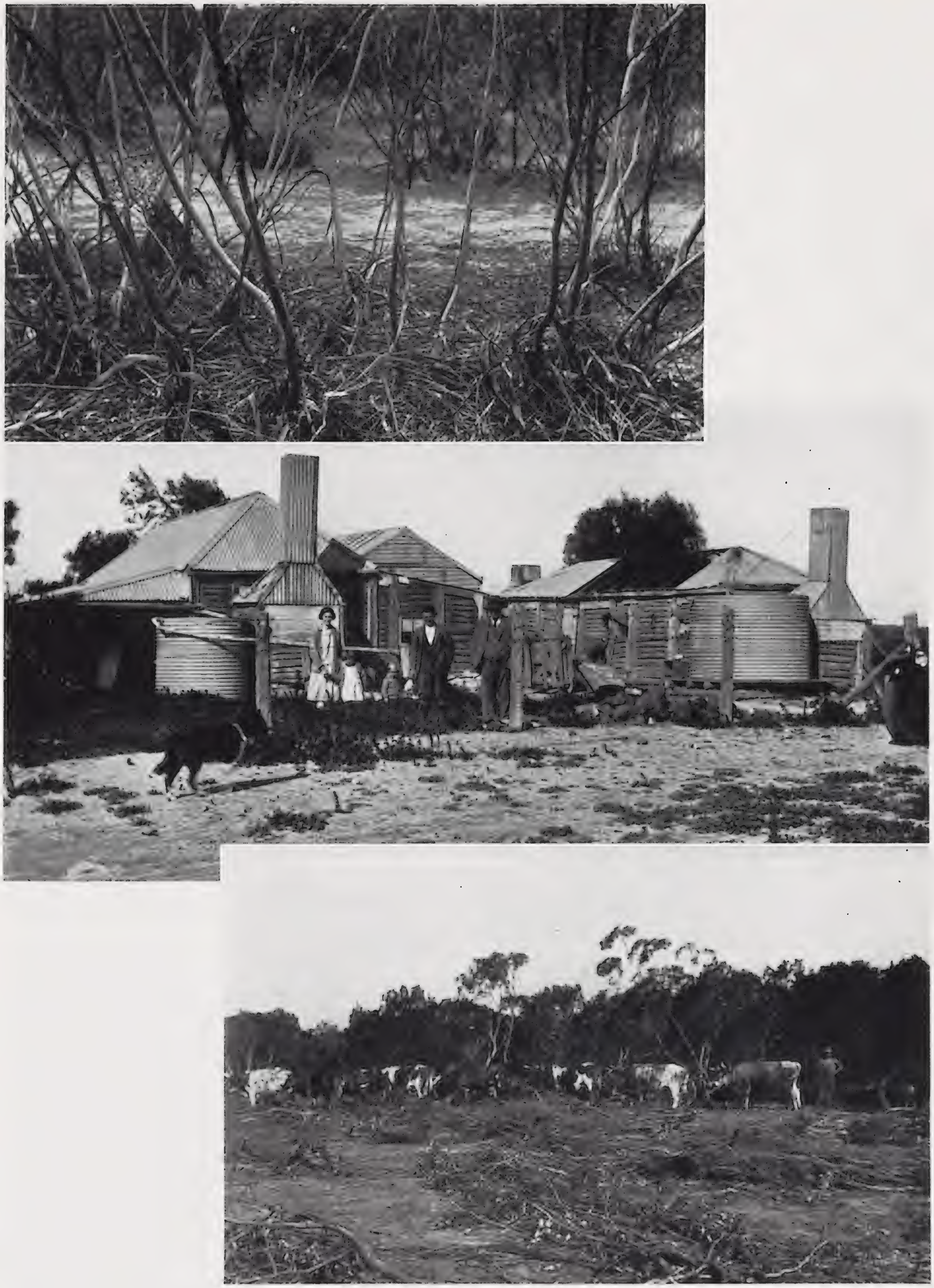
"This remarkable bird," Gould wrote of the Lowan, nearly seventy years ago, "is among the most important of the ornithological novelties which the exploration of Western and Southern Australia has unfolded to us. Like the Wattled Talegallus, it is rendered highly interesting from the circumstance of its not hatching its own eggs, which, instead of being incubated in the usual way, are deposited in mounds of mixed sand and herbage, and there left for the heating of the mass to develop the young, which, when accomplished, force their way through the sides of the mound and commence an active life from the moment they see the light of day."

We have learned much concerning the habits of the Lowan since Gould's "Handbook to the Birds of Australia" was published (in 1865); but this "outline" sketch has only been filled in, as it were, and we are planning, even now, further team observations. A mound must be watched, day-long, throughout building time and the actual breeding season.

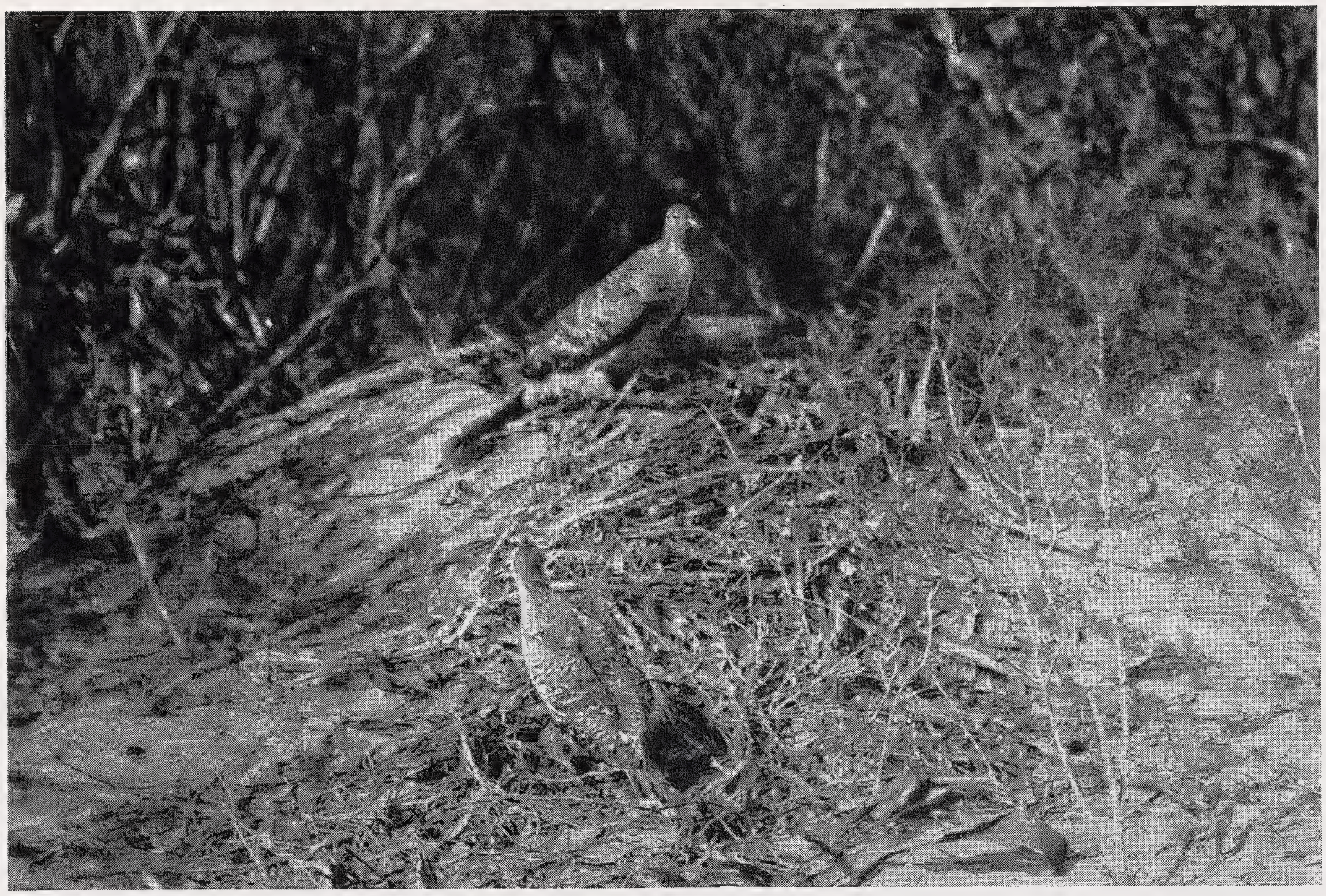
Sir George Gray, explorer and, later, a Colonial Governor, one of Britain's vice-consuls of Empire—was a pioneer observer of the mallee-fowl "at home," and in a letter to Gould, dated September, 1842, gave a detailed description of the nest-mounds. It was in the Wongan Hills, western Australia, that Sir George found Ngou-oo, or gnow (aboriginal name for *Leipoa*) hillocks, in the midst of dense scrub. The Wongan Hills are about 1300 feet above sea level, and their slopes are covered in gum trees, while for miles around extends the mallee scrub.

The Lowan, though always forming its mounds in the seclusion of the scrub, favoring the densest places, is not confined to it, but frequents also the more open tracts and those wide sunlit valleys between the dunes that are

The monitors of Australia are confirmed marauders, large, powerful and active. As their diet includes the eggs of various birds, they work great havoc among the mounds of Megapodes. Their uncanny instinct in detecting the presence of eggs in the mounds of the turkeys, has made them formidable enemies of these isolated and unprotected nests and frequently they make use of these natural incubators as a repository of their own eggs. An interesting instance of two widely separated living forms from the Reptilian stem using the same medium for the incubation of their eggs. Photograph by Charles Barrett.



In the Mallee scrub country of Victoria. The picture at the top is a bit of typical mallee scrub, a haunt of the Mallee-fowl—Lowan—and where this species constructs its nesting-mounds. The scrub is a species of mature, dwarf Eucalypt—Mallee gum trees. In the center is a settler's home in the Mallee country which has been cleared of the scrub for cultivation. The lower picture shows the method employed of rolling down the scrub to clear the land. As the land is cleared, the nesting sites of the Mallee-fowl are destroyed, thereby forcing the birds farther back into the wilderness to seek more isolated areas. Photographs by Charles Barrett.



Nesting mound of the Mallee-fowl. A rare and unusual photograph showing this shy bird on the mound filling in the egg-chamber with twigs and decayed vegetation. A second bird is standing just at the edge of the mound. Evidently this is a pair both at work on the nesting site. These nests are made about August and both birds assist in their structure. With other species the male alone does most of the work. The male and female Lowan differ very slightly in their markings, and their color harmonizes so closely with their surroundings that they are rarely seen. Photograph by the late C. H. McLennan.

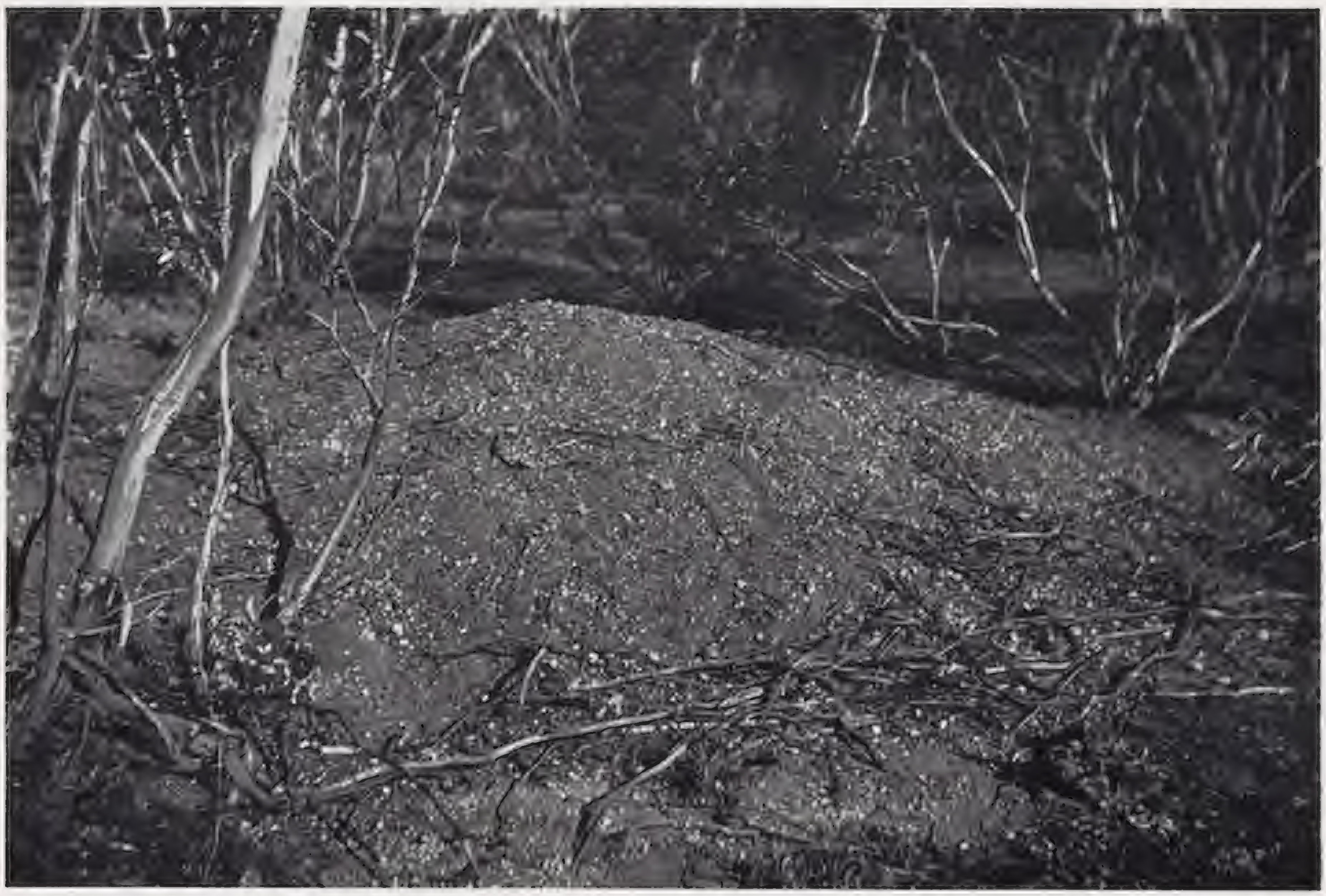
wild-flower gardens in the Spring. I have met with our mound-builder even close to a settlement, in a small, uncleared area, and seen it run across a roadway. Still it is shy and wary, and one obtains merely glimpses of the Lowan, unless observing from a hide near the mound.

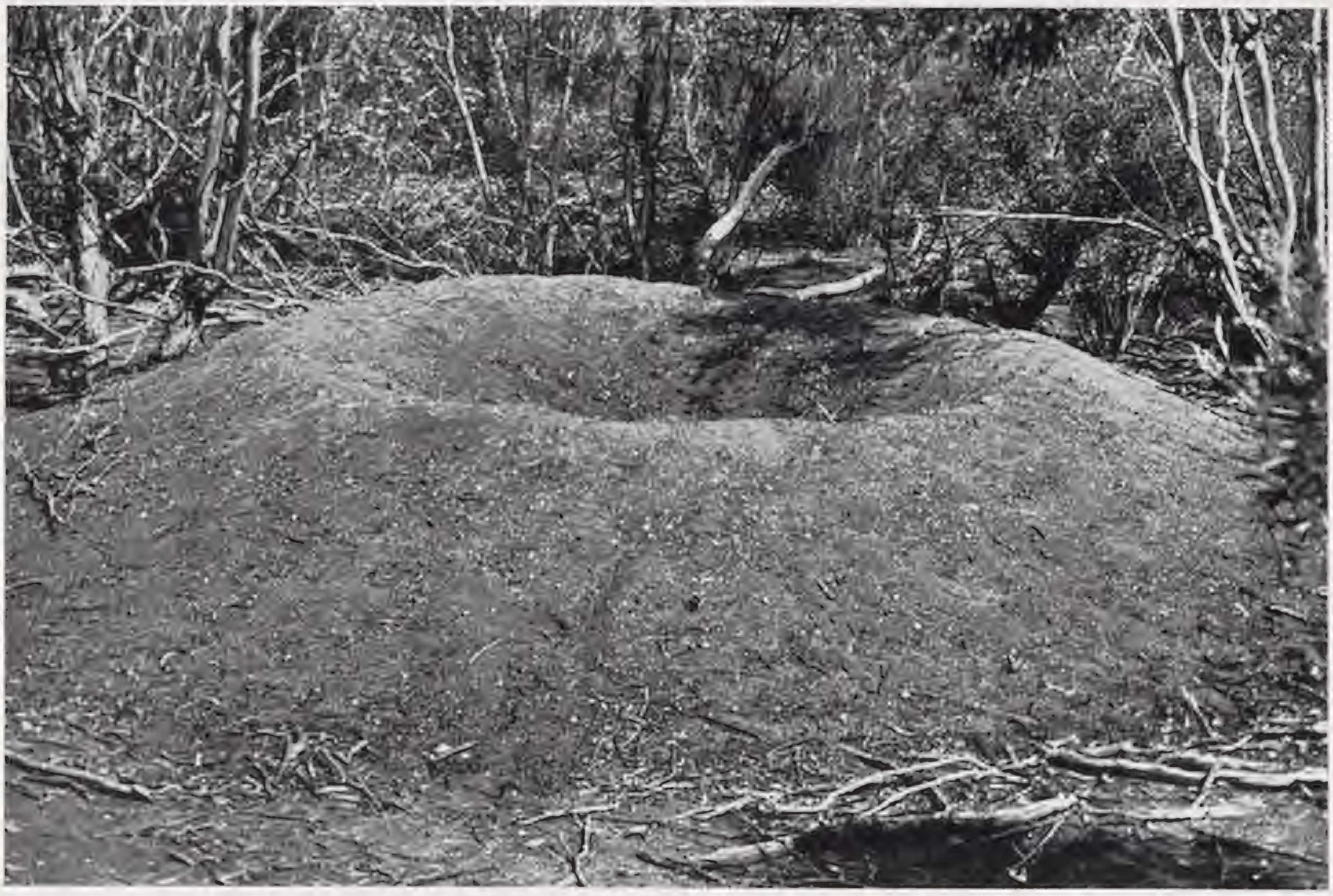
Rather like a small hen turkey, in size and general appearance, the Mallee-fowl is charmingly colored: back and wings are spotted black, white and brown; the neck is of a light fawn-grey color, and bare portions of the head and face are delicate blue; the eyes are light hazel, but brilliant; legs and feet, dark brown. The Lowan eats the seeds of shrubs of different species, the leaf-buds of one or two kinds, and berries, also insects, including ants, which abound in its haunts, Phasmids, beetles, etc. Its gizzard is very hard and horny. Though able to go for long periods without moisture, excepting such as they obtain from foliage in the early morning hours, or from their insect victims, these birds drink on occasion—during or just after a rainfall. They are rapid runners, and dodge through the scrub, if pursued, for some distance, seldom taking wing. They roost on low branches—there are few high ones in their usual haunts.

Mounds may be very isolated, or several be formed by different pairs of Lowans, within a restricted area. Little more than two hundred yards separated two mounds I discovered near Ouyen, when that township was an infant settlement, an islet in a sea of scrub. The size of the mound varies a good deal; a fairly large one measures, at the base, over twelve feet in diameter and three or four feet in hight. I have seen mounds over 40 feet in circumference, and others much smaller.

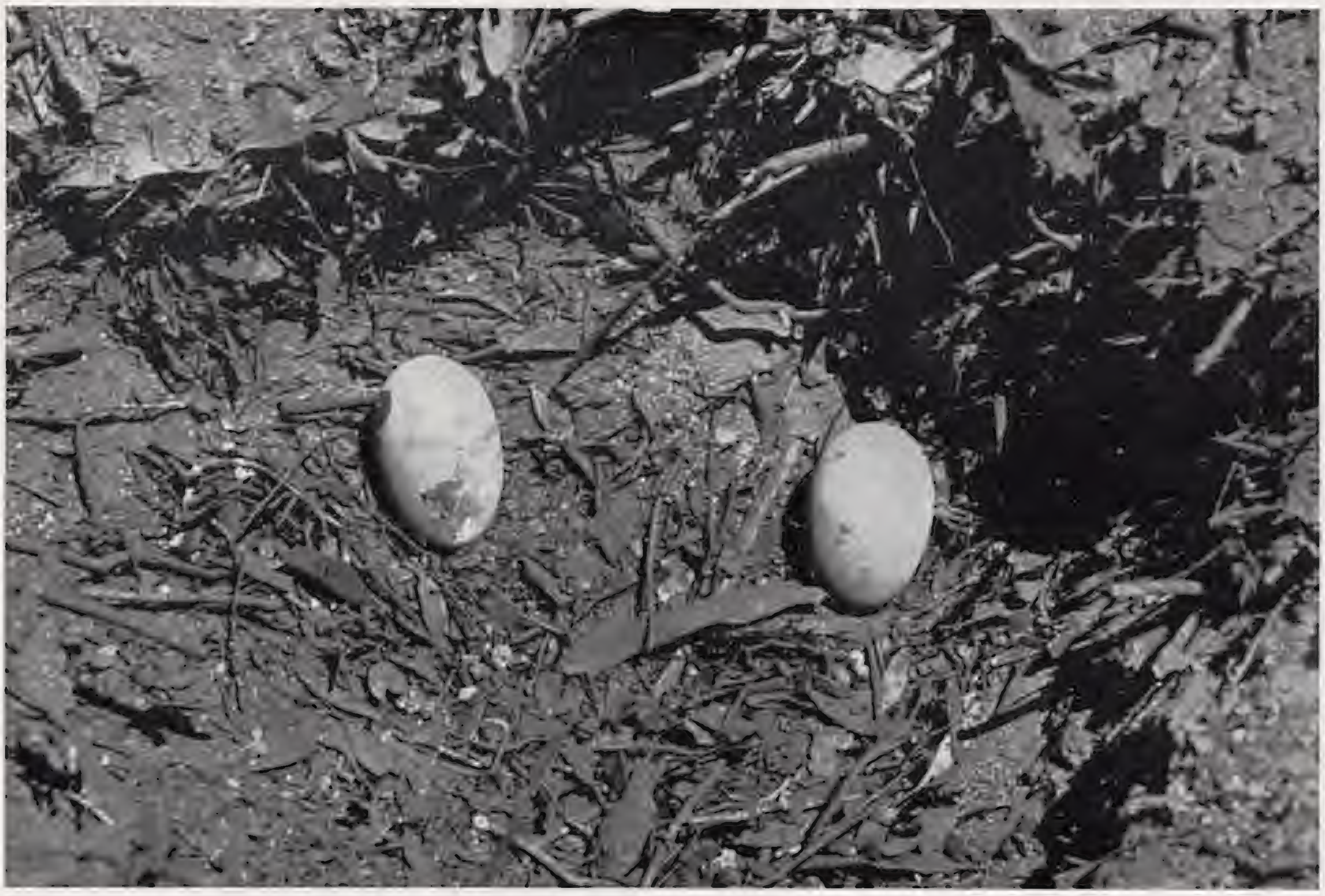
Though swift-footed at need, the Lowan's usual gait is dignified, a slow walk. It is mostly a silent bird, as befits its solitary habits: its subdued, soft note, uttered occasionally, is in tune with the spirit of the lonely mallee scrub.

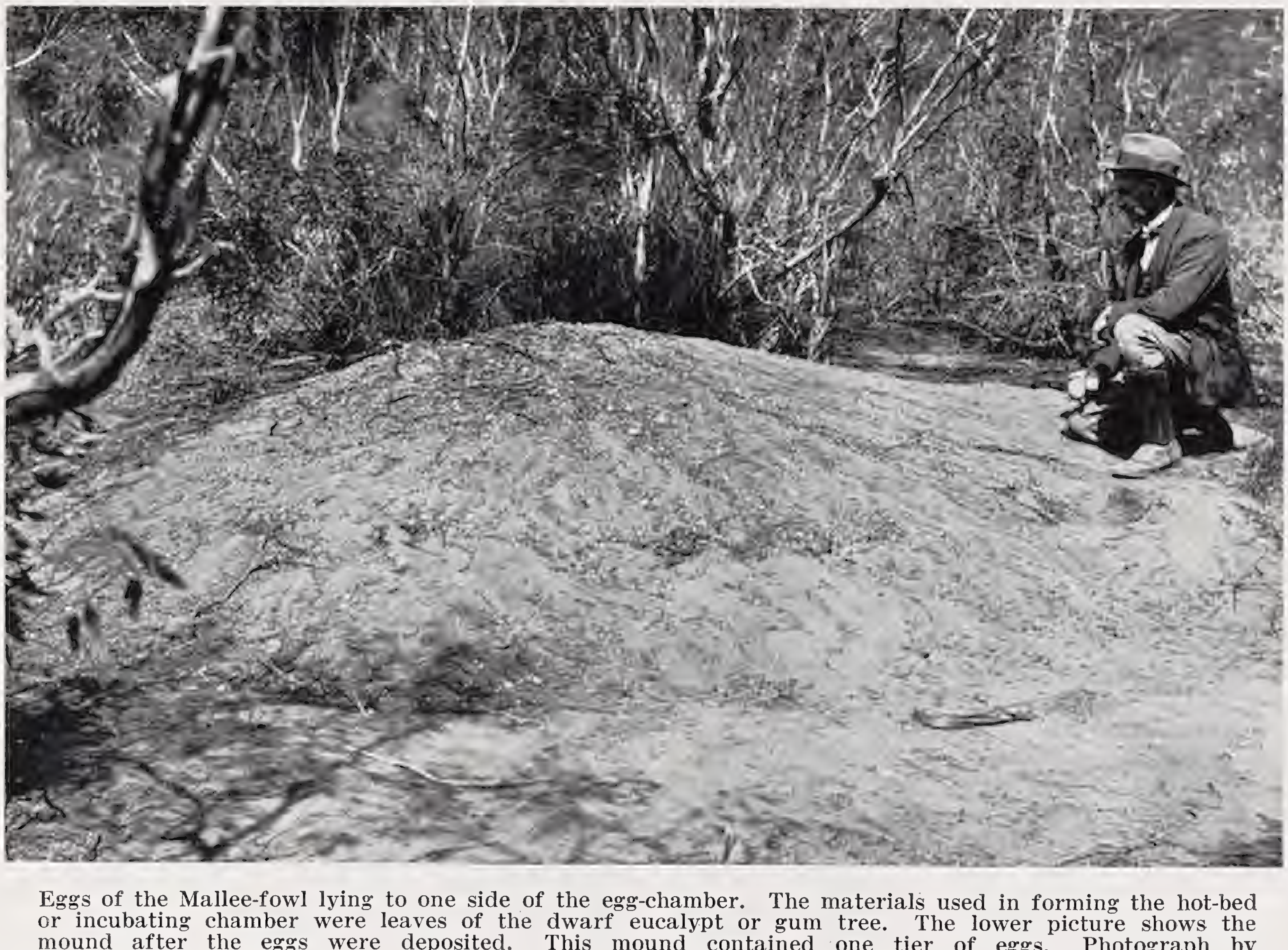
Much hard work goes to the making of a mound, and unless driven off by encroaching settlement, or otherwise disturbed by man, birds may use the same nest year after year. They are, of course, annual renovations. When a new



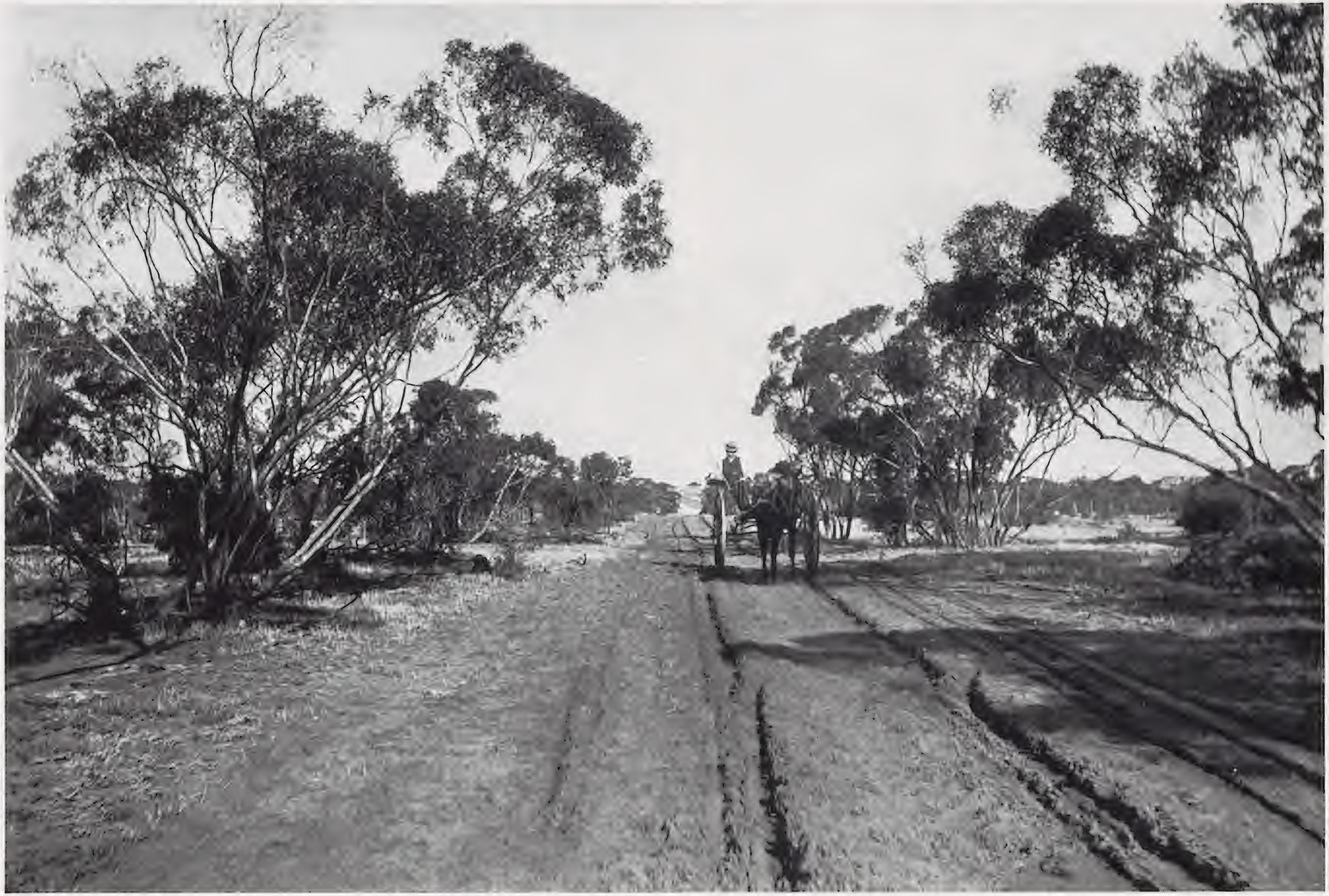


The pictures on this page and the two on the opposite one represent various stages of mound-building of the Mallee-fowl. The one at the top is a mound just completed, perhaps but a few days, and is generating heat in the hot-bed of decaying vegetation preparatory to the laying of the eggs. The lower picture shows the mound opened by the birds down to the egg-chamber.





Eggs of the Mallee-fowl lying to one side of the egg-chamber. The materials used in forming the hot-bed or incubating chamber were leaves of the dwarf eucalypt or gum tree. The lower picture shows the mound after the eggs were deposited. This mound contained one tier of eggs. Photograph by Charles Barrett.



A road through the heart of the desert country of Australia. Although there are miles upon miles of trackless scrub and sandy wastes on both sides of the trail, Mallee-fowl are often seen and evidently find means of existence in this dry and desolate sandy region. In the preceding pictures it is apparent that after the egg-chamber is completed, sand is used to cover the chamber and forms the greater part of the mound. Photograph by Charles Barrett.

mound is required a hollow, perhaps two feet in width, and seven or eight inches deep at the centre, is scraped out of the chosen site. This depression is filled in with leaves and twigs and other debris, scraped off the ground around it, or brought from a distance: both wings and feet are used in gathering and transporting material. In the scrub one sees many trails, due to the Lowans' wing-sweeping and foot-scraping operations. They are most industrious as builders!

The hollow filled, the birds proceed to build up a low mound of the material—less than a foot above ground level, and in the centre of this make an excavation, perhaps six inches deep and over a foot across: the egg-chamber. Next comes mound-making proper. Sand, or dry grey earth mixed with sand in some localities, is heaped around the egg-chamber or nest, which then is ready for the rains. Work at the mound ceases until winter downfalls have soaked the heap of vegetable matter and other debris forming the "hot-bed," which may be several months after preliminary work in the autumn. Sand, then, is scraped over the mound to a depth of six inches or more, and another period of waiting follows, only a few days perhaps, while the decaying debris beneath the sandy dome, is generating heat. At length, all is ready for egg-laying, and the female bird scrapes a great deal of sand out of the egg chamber, leaving a two or three inch layer at the bottom.

I have opened many Lowan mounds, and found eggs in plenty, but as to the birds' mode of placing eggs in position, must quote my late friend, D. Le Souef: "She then lays her egg, and holding it upright with one foot, with the small end downwards, she scrapes the sand round it with the other foot until it can stand alone. The bird has to lean well back to enable her to use both her feet. She then covers the whole with sand."

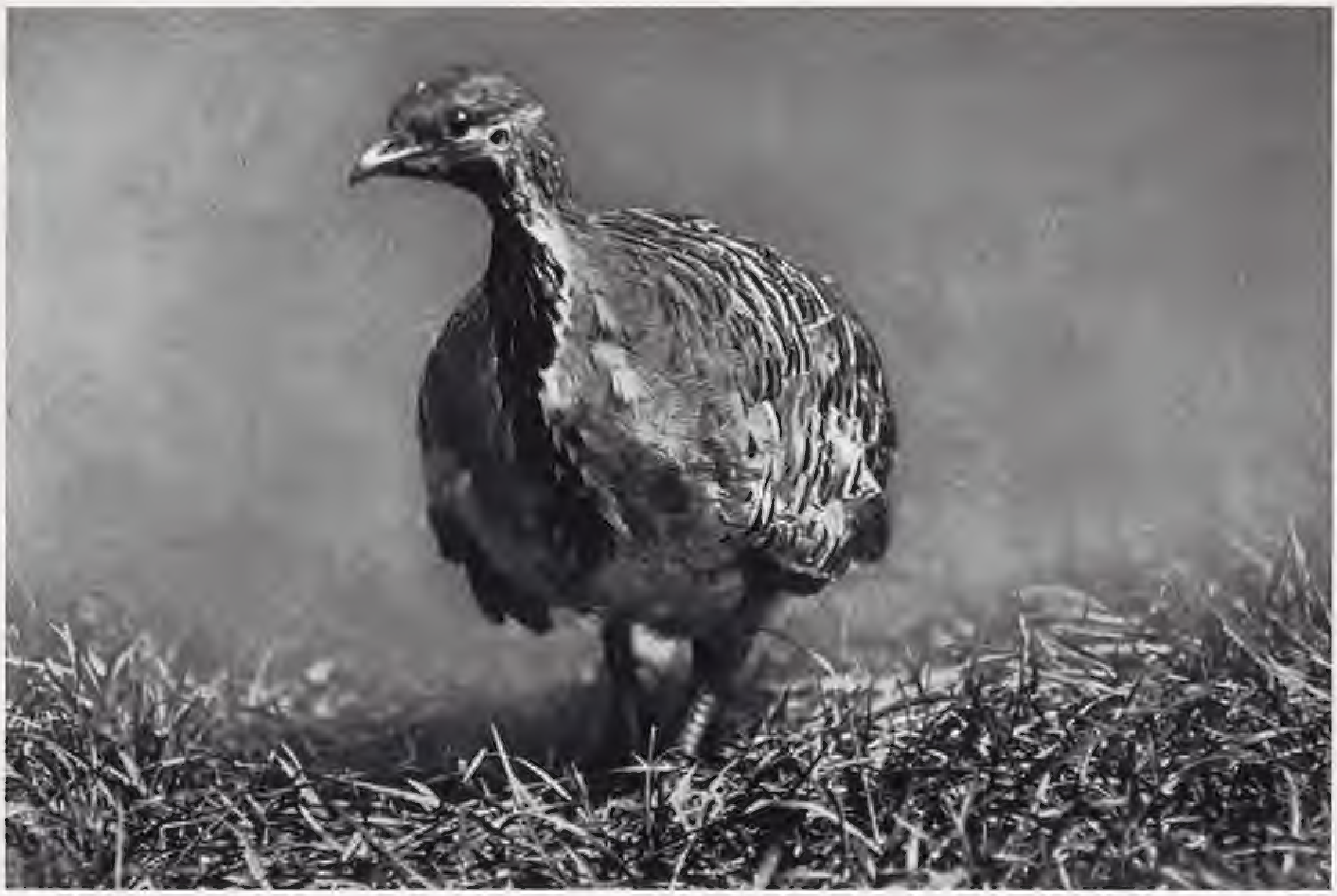
Whenever an egg is laid, the egg-cavity must be scraped out, and refilled. The eggs are deposited in tiers, usually at the outer edge of the cavity. When those first laid have been covered several inches deep in sand, another tier is begun. Three tiers are usual, each composed of three to five eggs. The full complement varies much, however from eight or nine or a dozen up to eighteen; the average being about fourteen. Dawn is the hour for egg-laying, at three-day intervals. The period of incubation extends over about five weeks. The temperature of the egg-chamber varies but slightly—95 deg. to 96 deg.

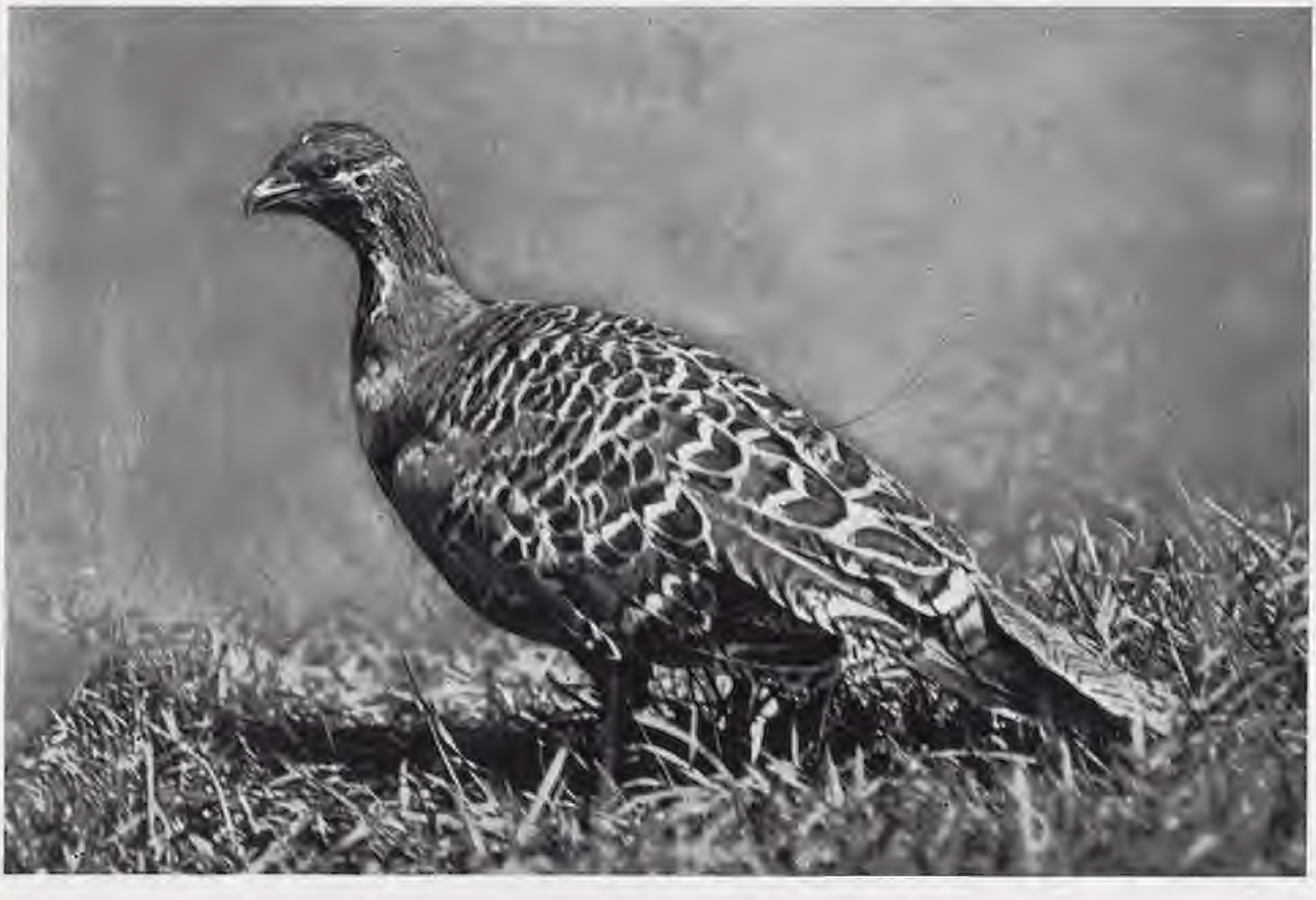
Lowan eggs are delicious, unfortunately for the species: in the days before protection under our Game Laws, nearly every mound discovered was robbed by the settlers; and even now, there is poaching of the kind. The eggs measure between three and four inches in length (3.73, 3.52, and 3.44, are sample measurements), and are elliptically inclined, or of a long oval shape. The very thin, coarse-textured shell is pale pink, or pinkish-buff colored when the egg is fresh, but soon darkens.

The young are so precocious that they run quickly when just out of their mound-nursery, and are even able to fly, their wing feathers being sufficiently developed to support them in the air over a short distance. They work their own way to freedom, according to some observers, while others believe that the old birds aid them. Certainly, the parents do open up the mound to some extent almost every day, and the heap of sand and debris thus never becomes set while in use. Chicks from eggs of the topmost tier have a fairly easy task in getting to the surface; those of the lower tiers would benefit by parental aid. Dead chicks are found in a mound occasionally. The late C. H. McLennan, a Bush naturalist and keen observer, widely known as "Mallee Bird" (his pen name), often watched Lowans at their mounds, and took the unique photograph here reproduced. The birds, he recorded, have a habit of flattening out the "nest" at about 10 o'clock in the morning, in order to admit the heat of the sun, and about 3 P. M. building it up again.

Foxes (introduced, for sporting purposes, from England) are enemies of the mallee-fowl: they dig into the mounds after eggs. I have found evidence of their raids at many a mound. The big Monitor lizards (goannas) also rob the Lowan of its eggs, but man has been the worst enemy since the era of progress began in north-western Victoria and other parts of the wonder-bird's range.

When a new area is thrown open for settlement, clearing begins on the blocks (640 acres each), the virgin scrub being actually rolled down in swathes, almost as easily as wheat falls to the harvester. Stems of the dwarf mallee eu-





Ocellated Megapode (*Leipoa ocellata*) in the Zoological Park. In captivity this bird lacks the stamina of the Brush-turkey. The gray, fawn and black color-pattern is distinctive of this species. A nesting habit of one of the Megapodes of the out-lying islands is interesting as opposed to that of *ocellata*. Instead of erecting a mound, a hole three or more feet in depth is made in the sands along the shore above high-water and a single egg deposited about every twelve days, until six or eight have been laid, which eventually are hatched by the heat of the sand.

calpts are brittle at the root, and the great log or iron roller, drawn by a team of bullocks or of horses, smashes them down—it is the Juggernaut of the mallee. Lowan mounds do not escape; they may be rolled nearly flat, and hundreds of small birds' nests are destroyed completely by the ruthless roller. When the rolled scrub has become dry enough, it is burnt; and grubbing out the roots—in great demand as fuel—is the final clearing operation on a settler's block.

A Victorian Shire is called Lowan, the aboriginal name for the mallee-fowl, and one of the most musical in any Australian tribe's vocabulary.

At my request, the Chief Inspector of Fisheries & Game for Victoria (Mr. F. Lewis) wrote especially the following account of the present status and future prospects of the Lowan in the State:—

"The Lowan or Mallee-fowl was once very common in what is known as the Mallee section of Victoria, but of late years a very big proportion of this country has been cleared for the purpose of growing wheat. A large section of the Mallee country is considered, at the present time, unfit for settlement, and in these parts the Lowan is still fairly common in spite of the depredations of the imported fox and of the settler in search of fresh eggs.

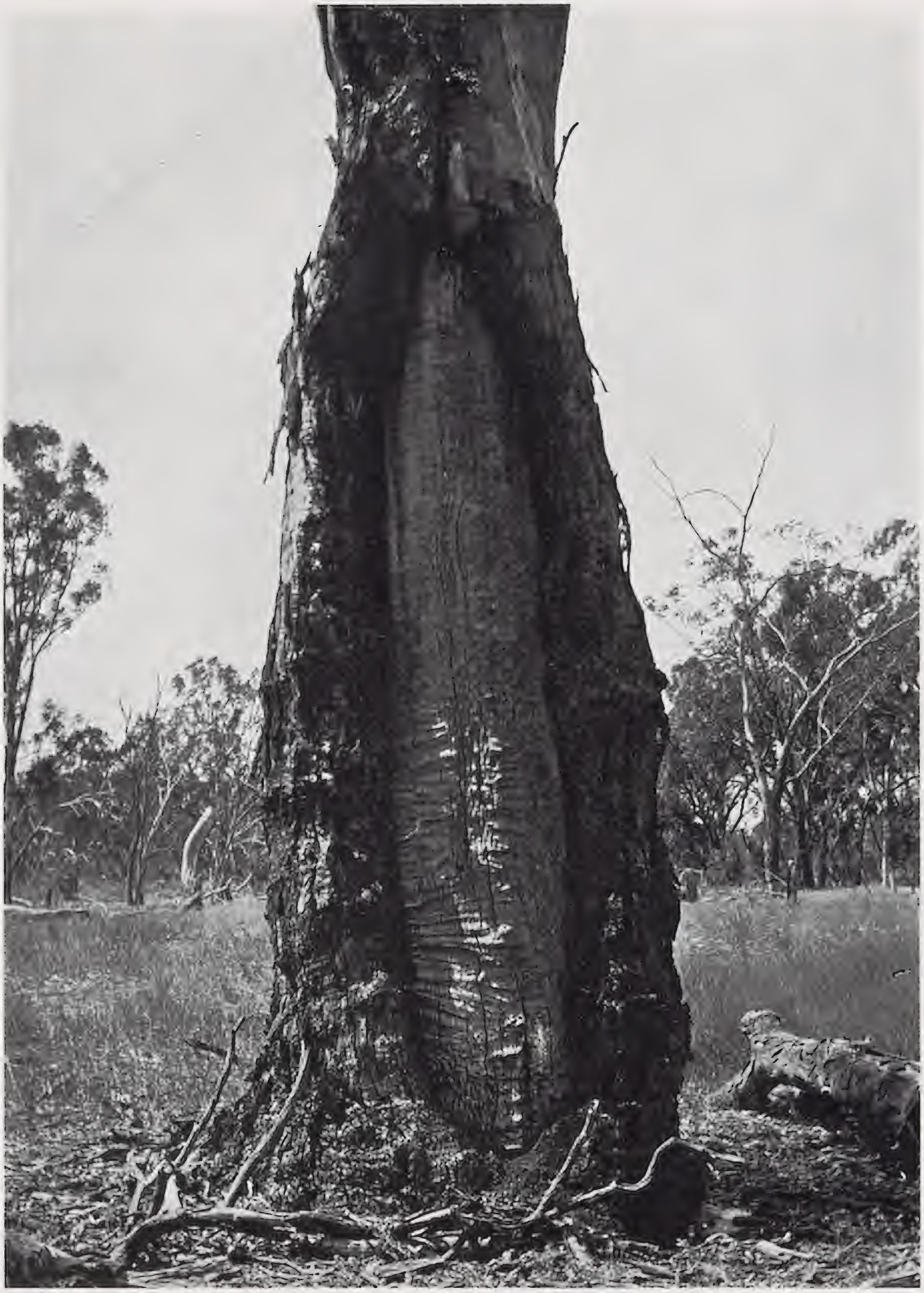
"It is most likely that, for a good number of years yet, a considerable portion of the drier parts of the Mallee will remain unsettled, and as long as this is so the Lowan will continue to exist. Should there come a time, however (and it is not at all improbable that this will eventuate) when improved methods of cultivation will enable the drier portion of the Mallee to be settled, the position of the Lowan will then be very precarious. The education of the public will probably result in the bird and its eggs not being interfered with by man, and the losses by the fox, judging by present experience, are not very serious, so that the most important factor in the preservation of the bird or otherwise is the spread of settlement.

"To counteract this it will be necessary to make large reservations of typical Mallee country before it is all alienated. There is at the present time a large National Park in the Mallee which, so far as it goes, is excellent. The greater part of this Park being composed of the valley of a river which once flowed through this country is not typical Mallee and therefore unsuitable for the breeding and preservation of the Lowan. To preserve this most interesting and unique member of our fauna, further reservations of typical Mallee country should be made at once. If this is done, I see no reason to fear the ultimate loss of this bird. If these reservations are not made it will only be a matter of time before the Lowan will disappear, from Victoria at least."

◆

Encourage Vireos.—During the summer almost anywhere in the United States at least one species of vireo, and usually more than one, is to be found flitting about in the trees or shrubbery. In the East and Central regions the common species is the red-eyed vireo, but the white-eyed, warbling, and yellow-throated vireos also are abundant. The Philadelphia, blue-headed, Hutton, and Bell vireos are more or less widely distributed. As with other common species of birds, the question as to whether or not vireos are beneficial is legitimately raised, and to answer it, the Biological Survey has made a study of their food habits.

The food of the several vireos is shown to be very similar though sometimes varying in proportions. Most of the insects eaten are either neutral or definitely injurious in their economic relations, and may be placed on the credit side of the account of these birds. All vireos are especially fond of caterpillars. Scale insects are a notable item of vireo food, and other tree pests are freely eaten. Many destructive weevils were found in the stomachs examined, including such forms as the cloverleaf, clover-root, cotton-boll, and nut weevils, the plum curculio and bark beetles. Vireos also destroy ants and grasshoppers. Useful insects taken by the vireos include some of the hymenopterans, predacious bugs, and beetles, among which are ladybird beetles, which are almost uniformly beneficial. Although it is regretted that vireos consume as many ladybirds as the evidence indicates, yet they also devour many of the pests attacked by the ladybirds, which must, in part, excuse them. As fruit eaters the vireos are practically harmless.



On the bank of the creek flowing along one side of the "Isle of the Dead" stands an old tree, known to the settlers of that part of the country as the "Canoe Tree." As the legend runs, over a century ago the aborigines cut from its trunk the bark for one of their primitive canoes. The serrations in the trunk indicate that the bark was lifted only after arduous labor, afterwards to be converted into a funeral craft ferried by an aboriginal Charon. Photograph by Charles Barrett.

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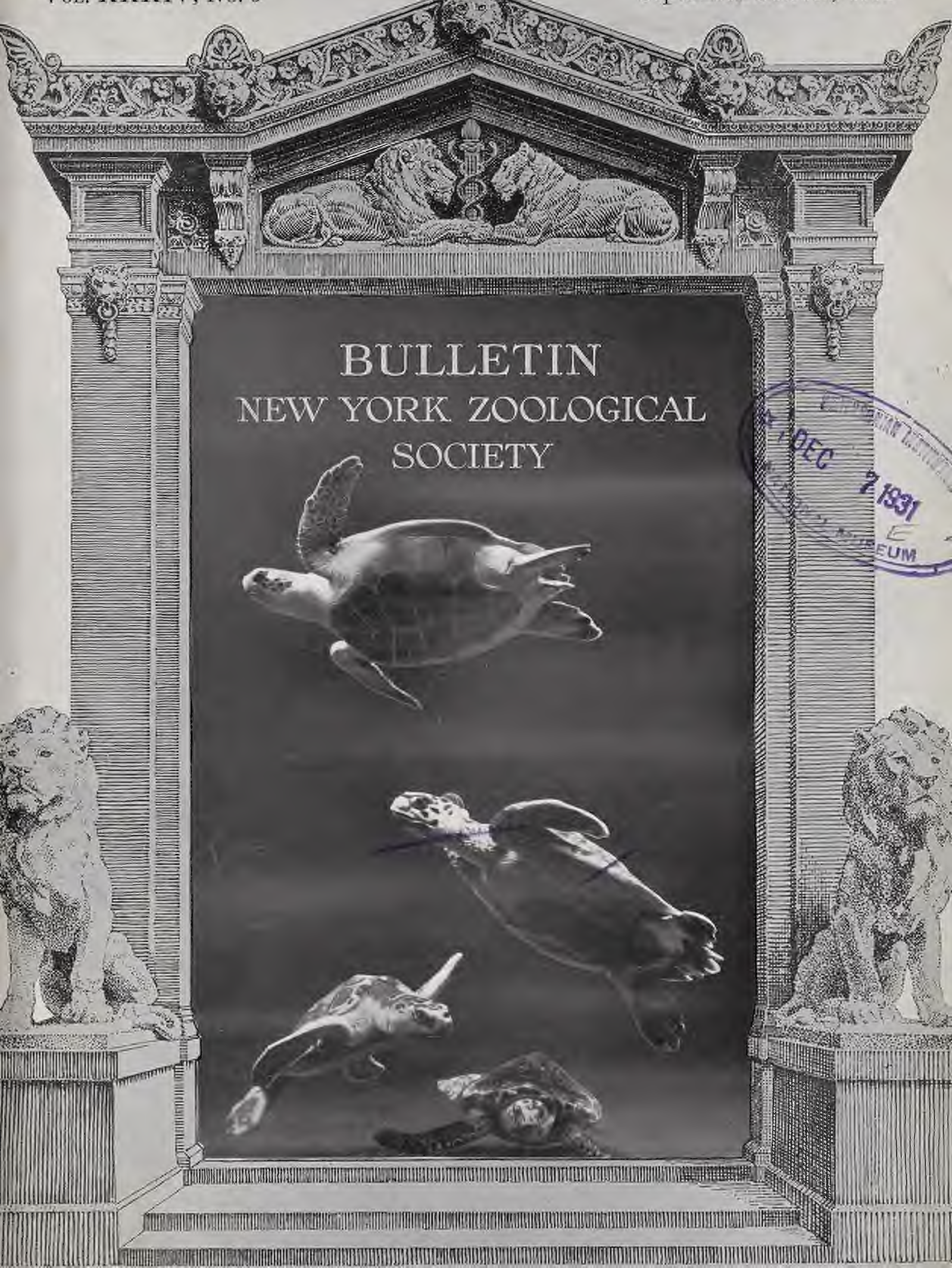

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Mud Box Terrapin
Musk Terrapin

SEA TURTLES IN NEW YORK AQUARIUM . . . . *Cover*

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BULLETIN

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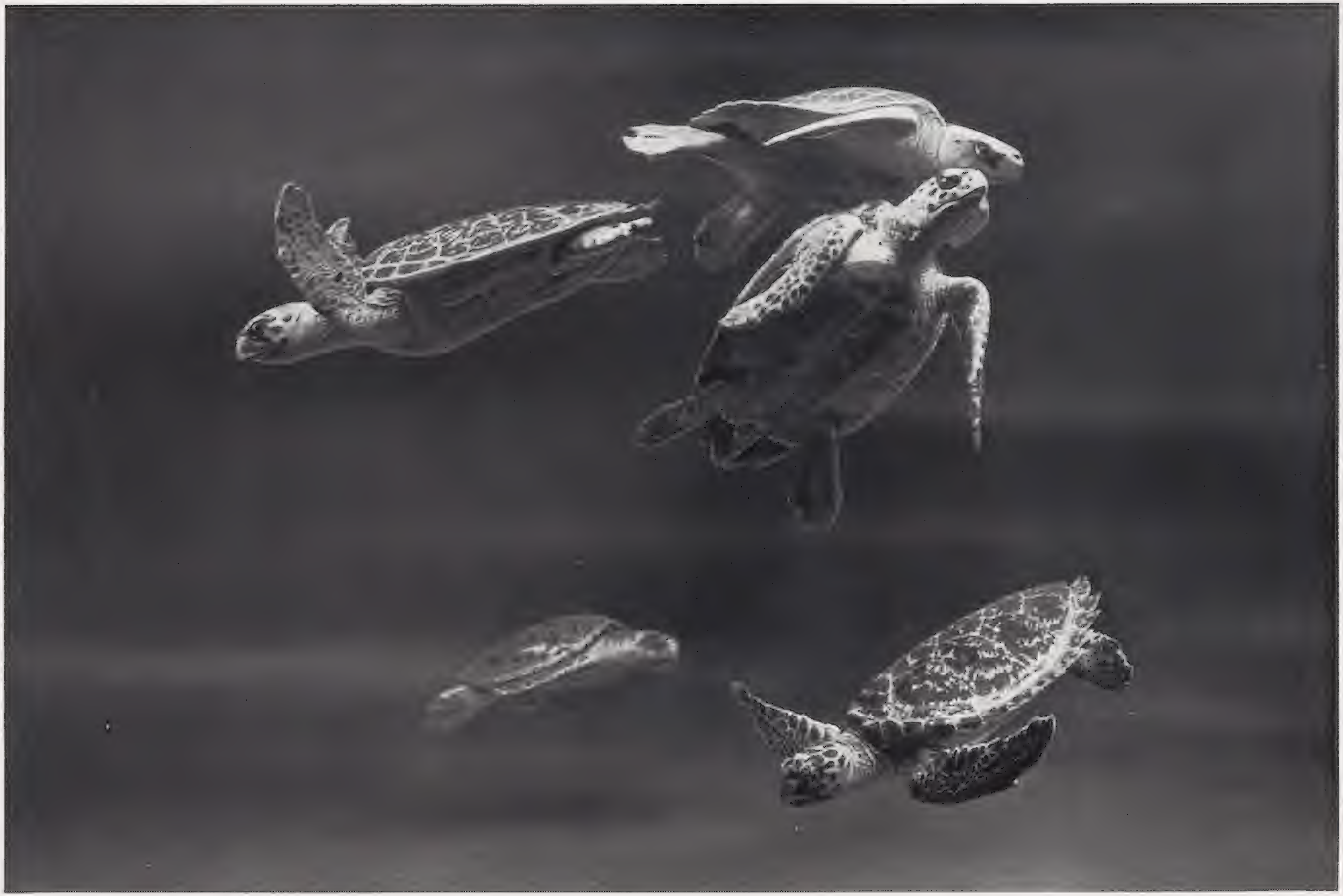

Sea Turtle Group, photographed in the New York Aquarium. Sea turtles are cosmopolitan in distribution, being found in all warm seas. They breed on the sandy shores of many islands and countries lying in the intertropical zone. The Pacific islands are favored as egg-laying spots and the West Indies are a counterpart to the East Indies in this respect. The specimens shown are Kemp's Bastard Turtle, a native American species found only in the Atlantic; and the Hawkbill, represented by two species, one in the Atlantic and the other in the Pacific. The saw-tooth edge of the darkly mottled shell is diagnostic of the Hawkbill (tortoise-shell turtle), while Kemp's species is a solid grey above with a pale colored head and underparts of a creamy white texture.

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The Turtles of the Northeastern States

The turtles and terrapins of the North Atlantic and New England States with a brief description of the various species.

C. RALPH DE SOLA

The illustrations in this article are from photographs in the collections of the New York Zoological Society, and were made from specimens in the Zoological Park and the New York Aquarium.

INTRODUCTION

THE northeastern coastal plain, or Atlantic slope, of the United States contains Maine, New Hampshire, Vermont, Massachussetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware and Maryland, and this region forms a zoogeographical entity as regards reptilian forms. The nineteen species of terrapins and turtles evenly distributed over this area have received little or no attention, existing accounts being scattered and hidden in the literature of herpetology. With the exception of Ditmars' "Reptile Book" written in 1907 and Babcock's "Turtles of New England" (1919), nothing can be found that treats upon the turtles of the North Atlantic states as a group. It is interesting to note that nineteen turtles ranging through eleven states are all within a two hundred and twenty-five mile radius of New York City.

Regarding the words "terrapin" and "turtle," the suggestion made by Dr. Hornaday has been adhered to in this article; he advises that all turtles having purely terrestrial habits be termed "tortoises," that all turtles leading an aquatic existence be termed "terrapins," and that all marine forms of the ocean be termed "turtles." This ruling has been used in the popular names which are followed by the taxonomic nomenclature devised by Stejnegar and Barbour in their "Check List of North American Reptiles and Amphibians."

Only turtles and terrapins are dealt with here as tortoises are restricted in their range to the warmer and somewhat tropical regions of our country. (See remarks on Box Terrapin). The sea turtles, although hatched in tropical waters of Central America, the West Indies and our own Southern coasts, are frequent summer visittants to Northern harbors and off-shore ocean waters. The terrapins, on the other hand, are native to the region under consideration and hibernate during the winter.

The sea turtles (Trunk-back, Kemp's, Loggerhead, Green, and Hawkbill) are to be found along the coasts of all states from Maine to Maryland.

The fresh-water terrapins (including Spiny Soft-shell, Soft-shell, Snapping, Box, Red-bellied, Western Painted, Eastern Painted, Map, Diamond-back, Muhlenberg's, Sculptured, Spotted, Mud Box and Musk) are distributed in equal abundance over the entire area. However, the local Diamond-back Terrapin is restricted to the coastal region from Massachusetts to Maryland.

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Turtles Found from Maine to Maryland, Including Vermont and Pennsylvania

Name of Turtle	States: New England	Vt.	NY & NJ	Pa.	Md.	Del.
SEA TURTLES						
Trunk-back Turtle *Dermochelys coriacea*	Xr	..	Xr	..	Xr	Xr
Kemp's Bastard Turtle *Caretta kempi*	Xr	..	X	..	X	X
Loggerhead Turtle *Caretta caretta*	Xr	..	X	..	X	X
Green Turtle *Chelonia mydas*	Xr	..	X	..	X	X
Hawkbill Turtle *Eretmochelys imbricata*	Xr	..	X	..	X	X
LAND AND POND TURTLES, TERRAPINS						
Spiny Soft-shell Terrapin *Amyda spinifer*	X	X	X	X	X	..
Soft-shell Terrapin *Amyda mutica*	..	..	..	X	..	..
Snapping Terrapin *Chelydra serpentina*	X	X	X	X	X	X
Box Terrapin *Terrapene carolina*	X	X	X	X	X	X
Red-bellied Terrapin *Pseudemys rubriventris*	X	X	Xr	X	X	Xr
Western Painted Terrapin *Chrysemys marginata*	..	..	Xr	X	..	..
Eastern Painted Terrapin *Chrysemys picta*	X	X	X	X	X	X
Map Terrapin *Graptemys geographica*	Xr	Xr	Xr	X	..	..
Diamond-back Terrapin *Malaclemys centrata concentrica*	Xr	..	Xr	..	X	X
Muhlenberg's Terrapin *Clemmys muhlenbergi*	Xr	Xr	X	X	..	..
Sculptured Terrapin *Clemmys insculpta*	X	X	X	X	Xr	Xr
Spotted Terrapin *Clemmys guttata*	X	X	X	X	X	X
Mud Box Terrapin *Kinosternon subrubrum*	X	X	X	X	X	X
Musk Terrapin *Kinosternon odoratum*	X	X	X	X	X	X
Total species by states:	17	11	18	13	15	14
Total species listed: 19						

(X indicates occurence of species in state)
(Xr indicates species is rare)

Key to the Identification of Turtles

Adapted after Pratt's "Manual of the Vertebrate Animals of the United States."

Class: REPTILIA: REPTILES—Back-boned, bilaterally symmetrical animals, covered with scales or plates.

Order: TESTUDINATA: TURTLES—Reptiles having jaws without teeth; whose wide and short bodies are enclosed in a shell made up of a top shield, the *carapace,* and a bottom shield, the *plastron.* Carapace and plastron are covered with horny plates and the head, neck and limbs of the body with scales.

Families, Genera and Species:

a-1 LAND and POND TURTLES: TERRAPINS—Aquatic turtles found on land and in the inland waters (ponds, streams, rivers and salt marshes); limbs not in the form of flippers.

b-1 Shell covered with horny plates.

c-1 Short tail without horny scales on top; plastron large and oval.

d-1 Plastron with 9 to 11 horny plates; margin of carapace turned downward, not flaring.

Mud Terrapins, *Kinosternidae,* genera *Kinosternon.*

e-1 Plastron very narrow and not covering the soft parts.

        f-1 Head with yellow stripes.
                Musk Terrapin, *K. odoratum.* (Fig. 19.)

    e-2 Plastron, covering the soft parts when closed.

        f-2 Head spotted with yellow.
                Mud Box Terrapin, *K. subrubrum.* (Fig. 18.)

d-2 Plastron with 12 horny plates; margin of carapace flaring outward.
        Sliders, Pond, Wood and Box Terrapins, *Testudinidae.*

    e-1 Plastron without hinge, immovably joined to carapace.

        f-1 Carapace usually keeled.

            g-1 Size small; mostly under 6 inches long; keel often indistinct.
                    Wood Terrapins, *Clemmys.*

                h-1 Carapace with small yellow spots on a black background.
                        Spotted Terrapin, *C. guttata.* (Fig. 17.)

                h-2 Carapace with deep concentric grooves in each plate and serrated behind.
                        Sculptured Terrapin, *C. insculpta.* (Fig. 16.)

                h-3 Head with a large orange or yellow spot on each side.
                        Muhlenberg's Terrapin, *C. muhlenbergi.* (Fig. 15.)

            g-2 Size moderate, carapace over 6 inches long.

                h-1 Salt marsh terrapins; plates with growth lines.
                        Diamond-back Terrapin. *Malaclemys.*

                    i-1 Shell rough, carapace dark olive in color.
                            Diamond-back. *M. centrata concentrica.* (Fig. 14.)

                h-2 Plates nearly smooth.
                        Map Terrapin. *Graptemys.*

                    i-1 Carapace depressed and with a keel; lower jaw notched at tip. Triangular yellow spot back of eye.
                            Map Terrapin. *G. geographica.* (Fig. 13.)

        f-2 Carapace not keeled, smooth. (See also *C. guttata.*)

            g-1 Carapace smooth, with rounded margin; size small.

                h-1 Carapace with red markings on marginal shields.
                        Slider Terrapins, *Chrysemys.*

                    i-1 Plastron immaculate yellow.
                            Eastern Painted Terrapin, *C. picta.* (Fig. 12.)

                    i-2 Plastron with blackish oval patch on yellow.
                            Western Painted Terrapin, *C. marginata.* (Fig. 11.)

            g-2 Carapace with serrated hinder margin.
                    Slider Terrapin, *Pseudemys.*

                h-1 Plastron red; lower and upper jaws serrated.
                        Red-bellied Terrapin, *P. rubriventris.* (Fig. 10.)

    e-2 Plastron with hinge across the middle, enabling the animal to close its shell.
        Body arched; plastron rounded behind; upper jaw hooked in front.
            Box Terrapin, *Terrapene carolina.* (Fig. 9.)

c-2 Tail very long, with top row of horny scales; plastron small, cross-shaped. Head covered with soft skin. Carapace with 3 blunt keels. Large head.
Snapping Terrapins, *Chelydra serpentina.* (Fig. 8.)

b-2 Shell not covered with horny plates, but with a leathery skin.
Soft-shell Terrapins, *Trionychidae.*

c-1 Fore part of carapace smooth; body brown in color, irregularly blotched.
Soft-shell Terrapin, *Amyda mutica.* (Fig. 7.)

c-2 Fore part of carapace with conical spines; body olive-brown, with numerous dark round spots, each margined with black.
Spiny Soft-shell Terrapin, *Amyda spinifer.* (Fig. 6.)

a-2 MARINE TURTLES, TURTLES: pelagic turtles found in the Atlantic Ocean along our coasts and occasionally entering our harbors; limbs in the form of flippers; size very large.

b-1 Shell covered with horny plates.
Sea Turtles, *Cheloniidae.*

c-1 Four costal plates on each side of the carapace.

d-1 Plates of carapace imbricated.
Hawkbill Turtle (Tortoise Shell Turtle), *Eretmochelys imbricata.* (Fig. 5.)

d-2 Plates of carapace not imbricated. Body olive or brown above and splashed with yellow.
Green Turtle, *Chelonia mydas.* (Fig. 4.)

c-2 Five costal plates on each side.

d-1 Body brown above, yellowish below; feet with two claws each.
Loggerhead Turtle, *Caretta caretta.* (Fig. 3.)

d-2 Body a uniform dusky brown; similar to *C. caretta,* but with ridges on the crushing surfaces of the jaws under the horny sheaths.
Kemp's Bastard Turtle, *Caretta kempi.* (Fig. 2.)

b-2 Shell covered with a smooth leathery skin; carapace with 7 longitudinal ridges.

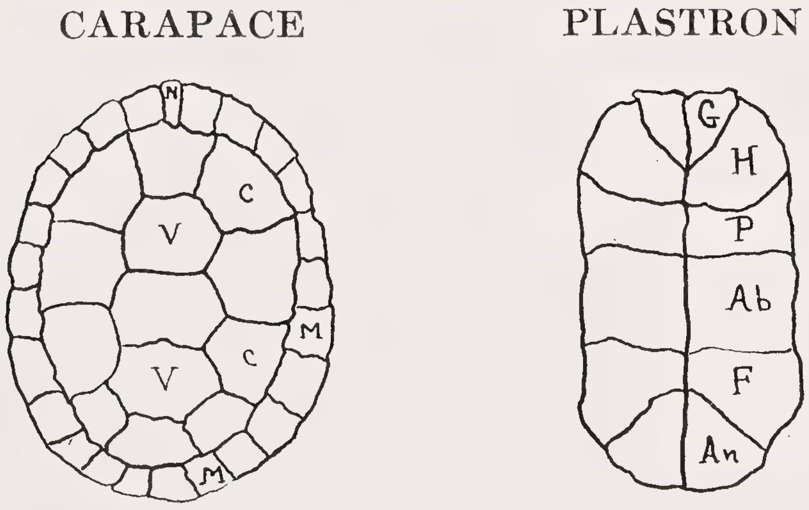
c-1 Color dark brown to black; weight often over 700 pounds.
Trunk-back Turtle, *Dermochelys coriacea.* (Fig. 1.)

Names of Turtle Shields Used in Identification of Species

Drawn from a typical species, the Western Painted Terrapin, *Chrysemys marginata.*

Note:—All measurements are taken along the straight line of the carapace or plastron. Size records given for each turtle are approximate.

Key:
N—nuchal shield
C—costal shields
V—vertebral shields
M—marginal shields



G—gular shields
H—humeral shields
P—pectoral shields
Ab—abdominal shields
F—femoral shields
An—anal shields

THE TRUNK-BACK TURTLE, *Dermochelys coriacea* (Linne), Fig. 1. This species occurs infrequently on our coasts and is the largest known to man in recent times, reliable records of weight being in excess of 1500 pounds. However, the average weight ranges from 700 to 900 pounds. It is unique among turtles in that neither the ribs nor the vertebrae are united to the carapace but are free within it. As seen from the key, this species is distinguished from all other marine turtles by the absence of horny plates, being covered with a tough leathery skin; thus it bears the same relation to the sea turtles that the soft-shell terrapins bear the other terrapins.

The trunk-back turtle, so named because of the seven ridges that give it that appearance, is of mythological interest. Sir John Hawkins, an eminent musicologist of the early nineteenth century, mentions a story of Homer in his "Harmonia Manualis":

> The lyre is the prototype of the fidicinal or stringed species of instruments and is said to have been invented about the year of the World 2000 by Mercury, who, finding on the bank of the river Nile a shell-fish of the tortoise kind, which an inundation of the river had left there, and observing that the flesh was already consumed, he took up the back-shell, and, hollowing it, applied strings to it.

Statues of Mercury often show the seven stringed shell mentioned by Homer and if they be of Greek origin, not only are seven strings shown but the hollow reverberating surface of the shell (the inner carapace) is molded so as to present seven distinct ridges.

Size and Color: Museum specimens have an average measurement of six feet from tip of snout to end of tail. The color of the body is a uniform dark brown occasionally spotted with yellow.

Habits and Economic Use: Little or nothing is known concerning the life of this pelagic form. Occasionally adult specimens are caught but it is not known where breeding takes place or what parts of the ocean are most favored for feeding. From the appearance of the very heavy notched jaws it has been assumed that its appetite is omnivorous. Its flesh is not used for food but Dr. Hornaday says that a pint of oil can be extracted from every square foot of the thick blubber-like coating overlying the bony carapace.

KEMP'S BASTARD TURTLE, *Caretta kempi* (Garman), Fig. 2. The bastard sea turtle is so named because it bears a resemblance intermediate to the green and to the loggerhead turtles. Many interesting but unrecordable tales are told concerning the origin of this species. It has no outstanding features inasmuch as its habits are like those of other sea turtles and its flesh is not valued.

Size and Color: Specimens taken in Lower New York Bay by the *Sea Horse,* the collecting boat of the New York Aquarium, measure from a foot and a half to two feet in length. The carapace is a uniform, dusky brown and the plastron is a whitish yellow. It is differentiated from the loggerhead turtle in that the crushing surfaces of the jaws under the horny knife-like sheathes are ridged.

Habits and Economic Use: For habits see accounts on green and loggerhead turtles. So far no commercial use has been found for the Bastard Turtle.

THE LOGGERHEAD TURTLE, *Caretta caretta* (Linne), Fig. 3. This, next to Kemp's turtle, is the commonest of the sea turtles and is frequently found off our coasts and entering our harbors. Its flesh is coarser than that of the green turtle and consequently is less sought after. It is, as its name implies, provided with a large head which serves to distinguish it from Kemp's and the green turtle. Pausanius confused it with the trunk-back or lyre turtle as he wrote:

> On Mount Parthenon in Arcadia, the Gods conserve the great turtles as sacred animals and only kill them when they need a shell which they find necessary in the construction of their lutes. The animals are guarded over by the god Pan.

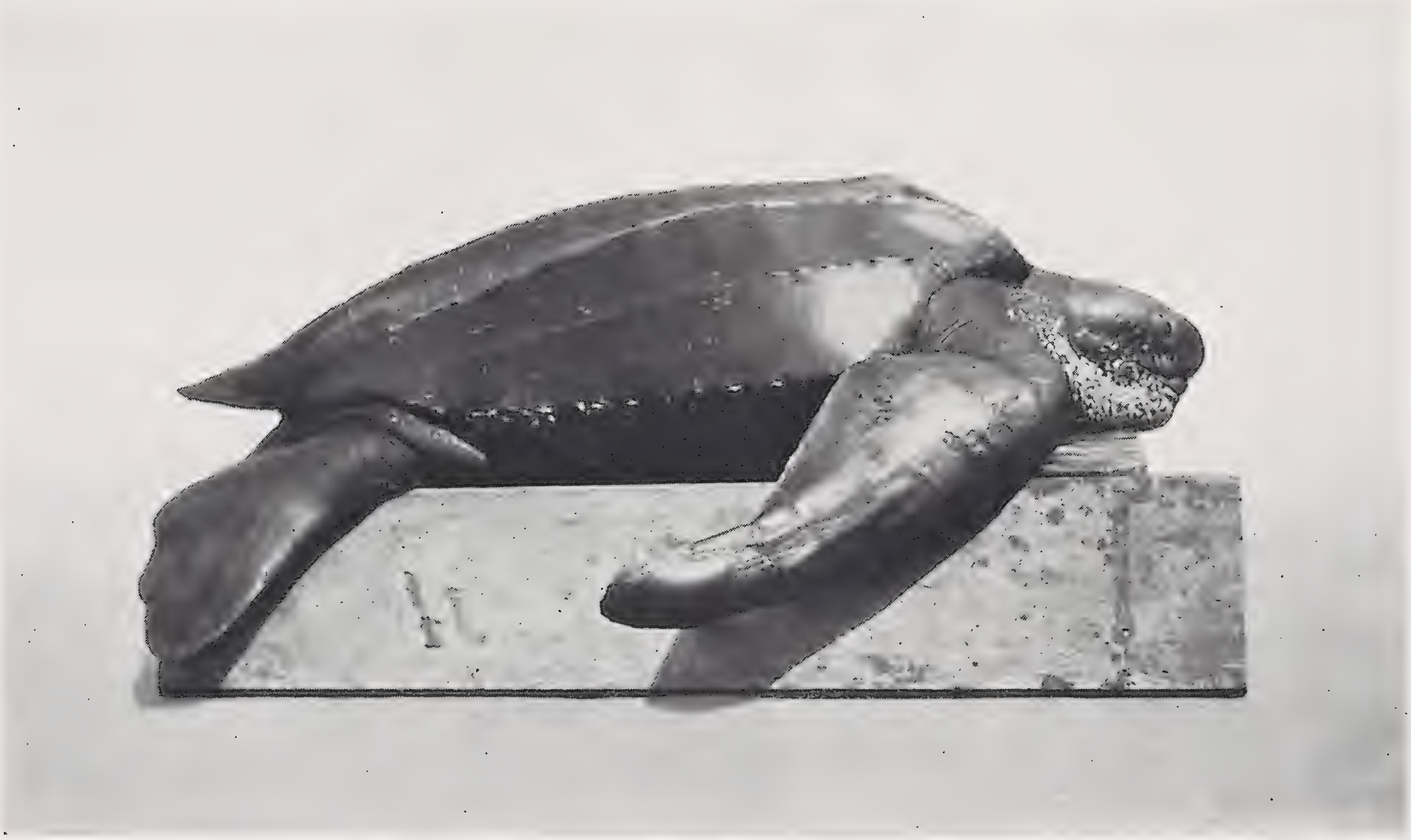
Another ancient writer, Corvilio Polio, credits himself with the invention of encrusting objects with the shell of the hawkbill turtle and knowing:

> . . . that the lens of the Loggerhead's eyes was valuable as a stone to mount in gold and use as a necklace that was much in demand by the rich Etruscan women.

Pliny who compiled Aristotle's observations on the breeding of sea turtles gives a number of recipes that he considers useful and that can be made from the several parts of the loggerhead.

Size and Color: Length of carapace usually over three feet. Specimens of this size weigh over two hundred pounds. The body is light brown above and yellow below.

Habits and Economic Use: The breeding



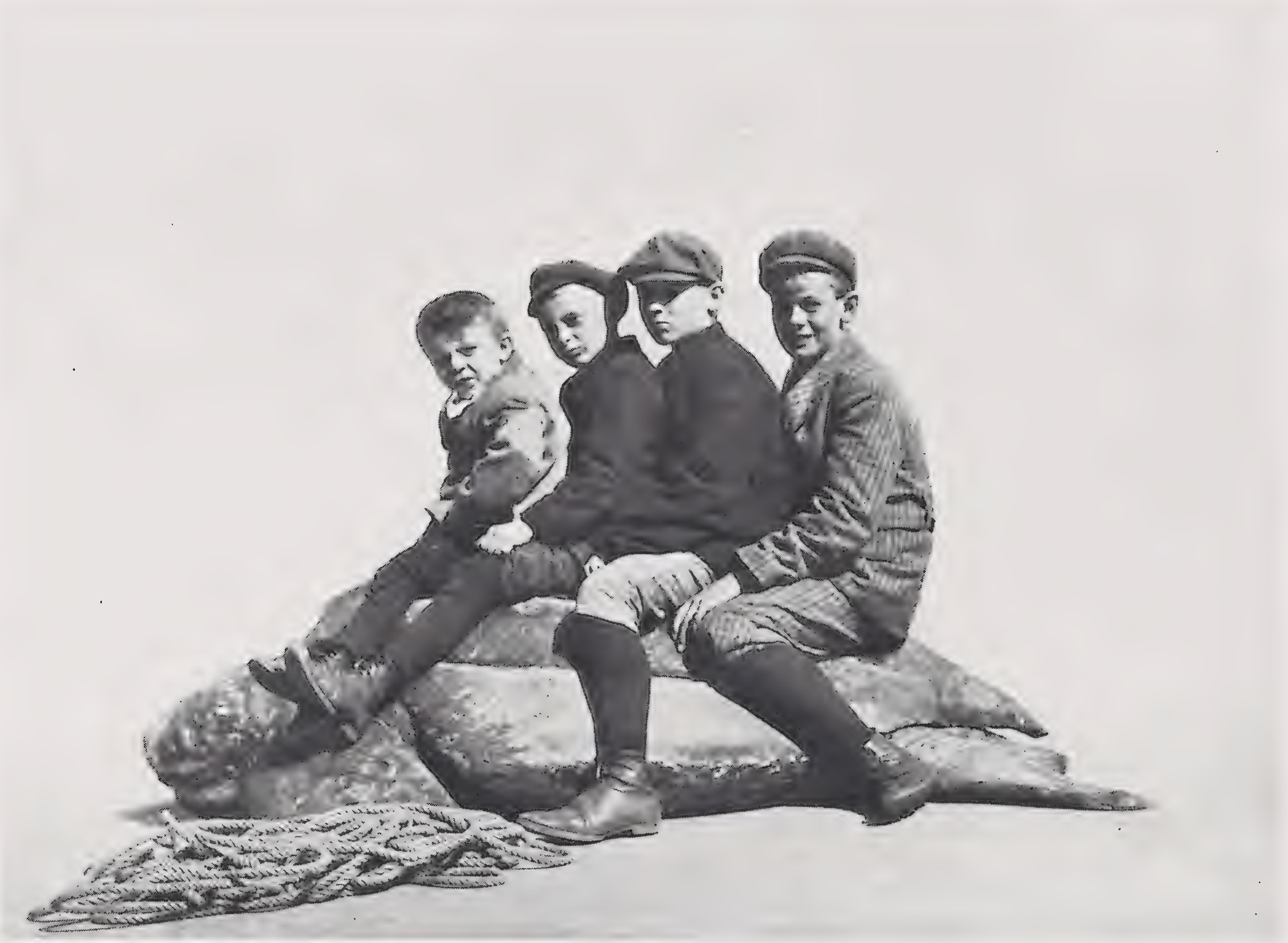


Fig. 1. Trunk-back Turtle, *Dermochelys coriacea*. Among the larger denizens of the deep the trunk-back turtle finds a place at par with dolphins, porpoises and sharks, being protected from their attacks by a hard, leathery shield and aided in locomotion by powerful swimming organs, flipper-shaped limbs. The photographs illustrate the gigantic proportions of this marine monster. In life this specimen measured over seven feet and weighed nearly half a ton. The species is little known in the annals of natural history, although it is the largest turtle of recent times.

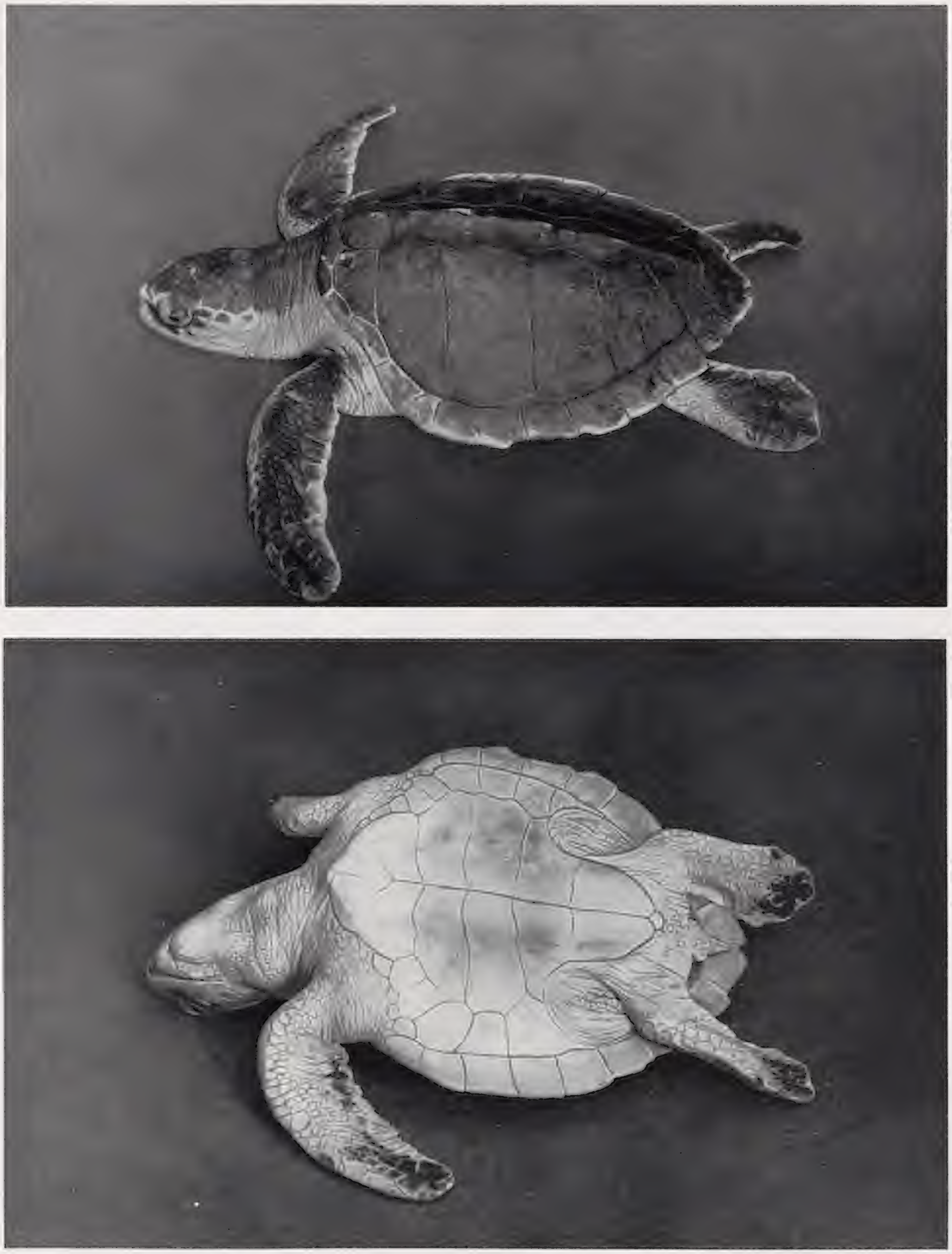
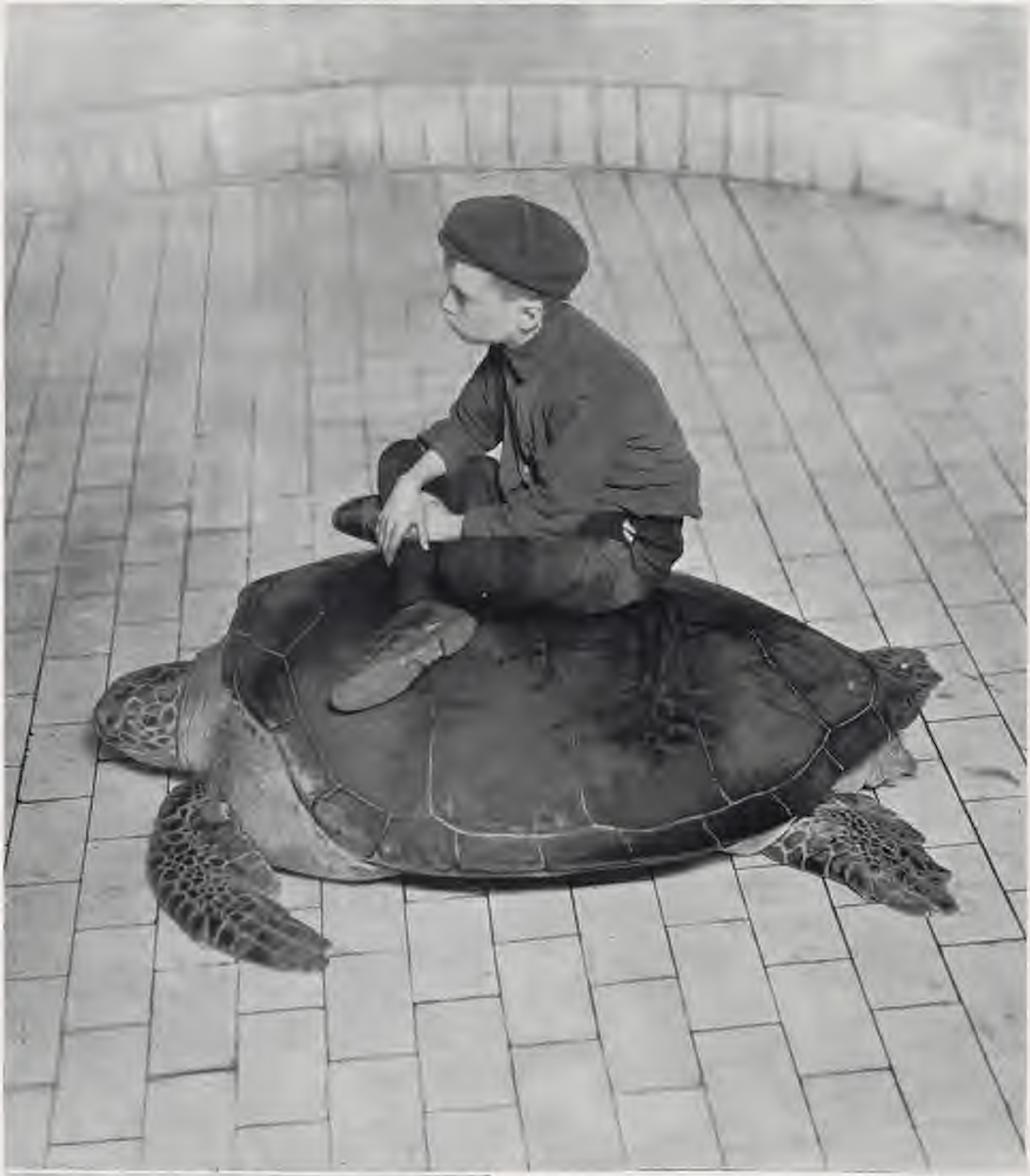


Fig. 2. Kemp's Bastard Turtle, *Caretta kempi*. This turtle was long considered to be the hybrid offspring of the loggerhead and hawkbill sea turtles. An allegation of this sort led to the appellative of illegitimate in the naming of what has been found to be a valid species. Individuals seldom exceed a length of two feet and specimens of that size weigh about fifteen pounds. Breeding occurs on the coast of Georgia during July with hatching taking place the following November. The Gulf Stream carries many of these turtles to our northern shores every summer. It is the species most commonly found in New York waters.



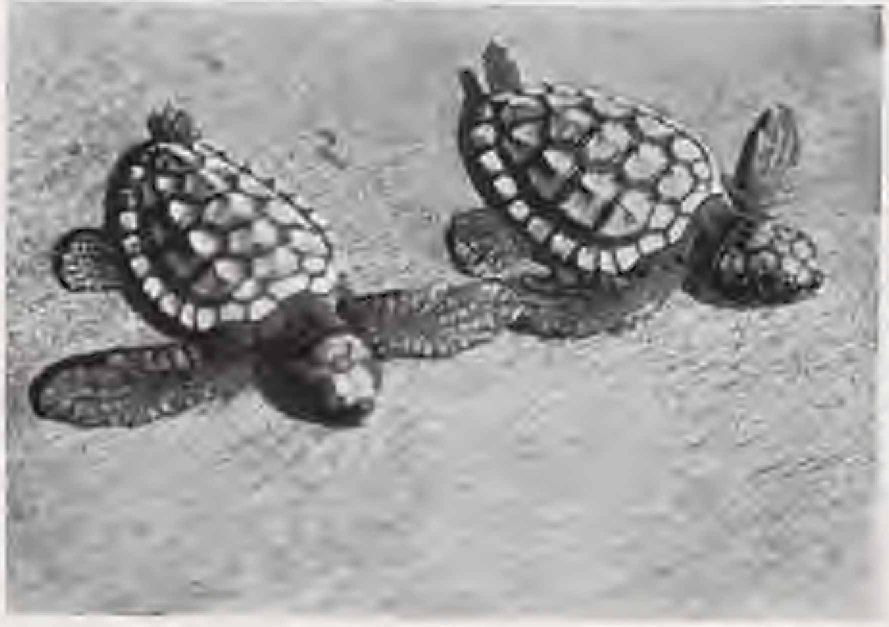
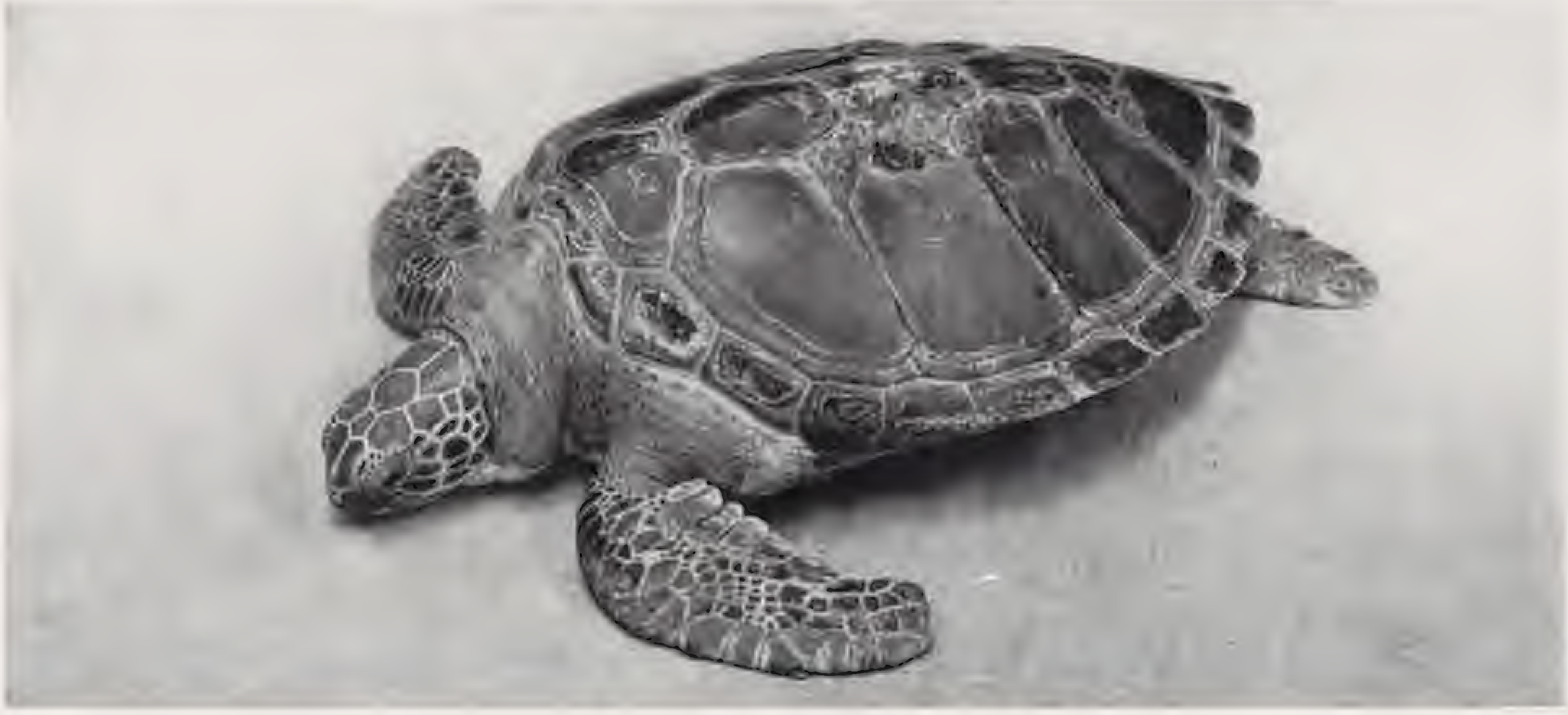


Fig. 3. Loggerhead Turtle and Young, *Caretta caretta.* The loggerhead is carnivorous and little esteemed for food. However, in many parts of the tropics its eggs are sought after and prized as a delicacy. The young loggerheads shown above differ from adult specimens in that their plates are imbricated and dark brown or blackish in color. Full grown specimens have a smooth carapace, a rich brown in tone, while the plastron is a clear yellow. Such individuals weigh about one hundred and twenty-five pounds and seldom exceed five feet in length. Considerable interest centers around the shield variations of this species. There takes place, during the lifetime of many individuals, a numerical reduction of the many small horny plates which, gradually becoming larger, afford the turtle a strong protective armor-like plating.



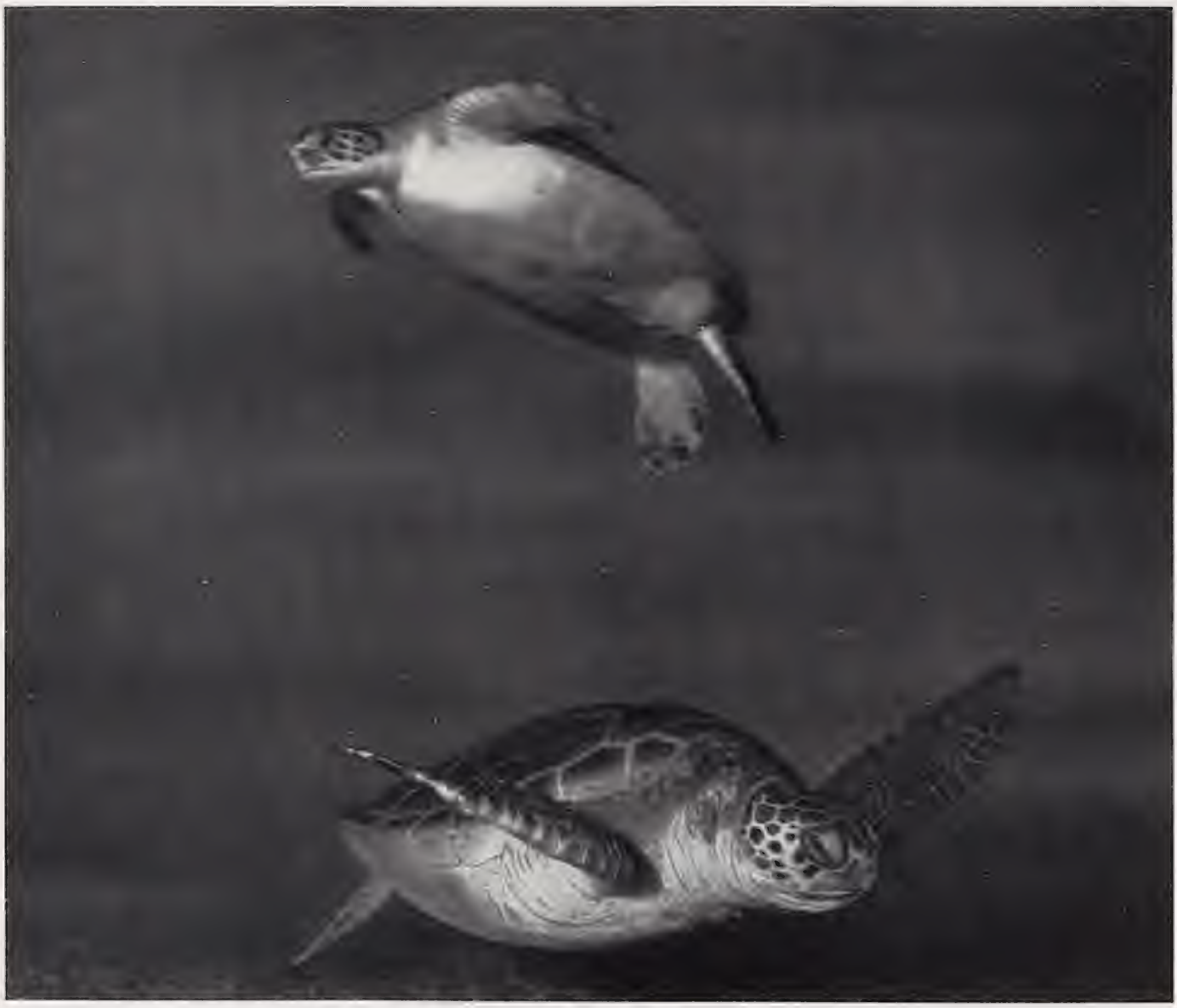


Fig. 4. Green Turtle, *Chelonia mydas.* This is the edible turtle valued the world round for its tender and succulent flesh. It has been hunted with such persistence that it is rapidly becoming extinct and another hundred years will find it relegated to museum storerooms and books dealing with recently extinct animals. The top view gives some idea of the size and bulk of the creature, while the bottom illustration depicts the underparts of this valuable marine reptile. These turtles are shipped to the New York markets from West Indian and Central American ports, while Europe receives her share from the shores of West Africa and Ascension Island, which is a famous center for the commercial operation of turtle fishing.

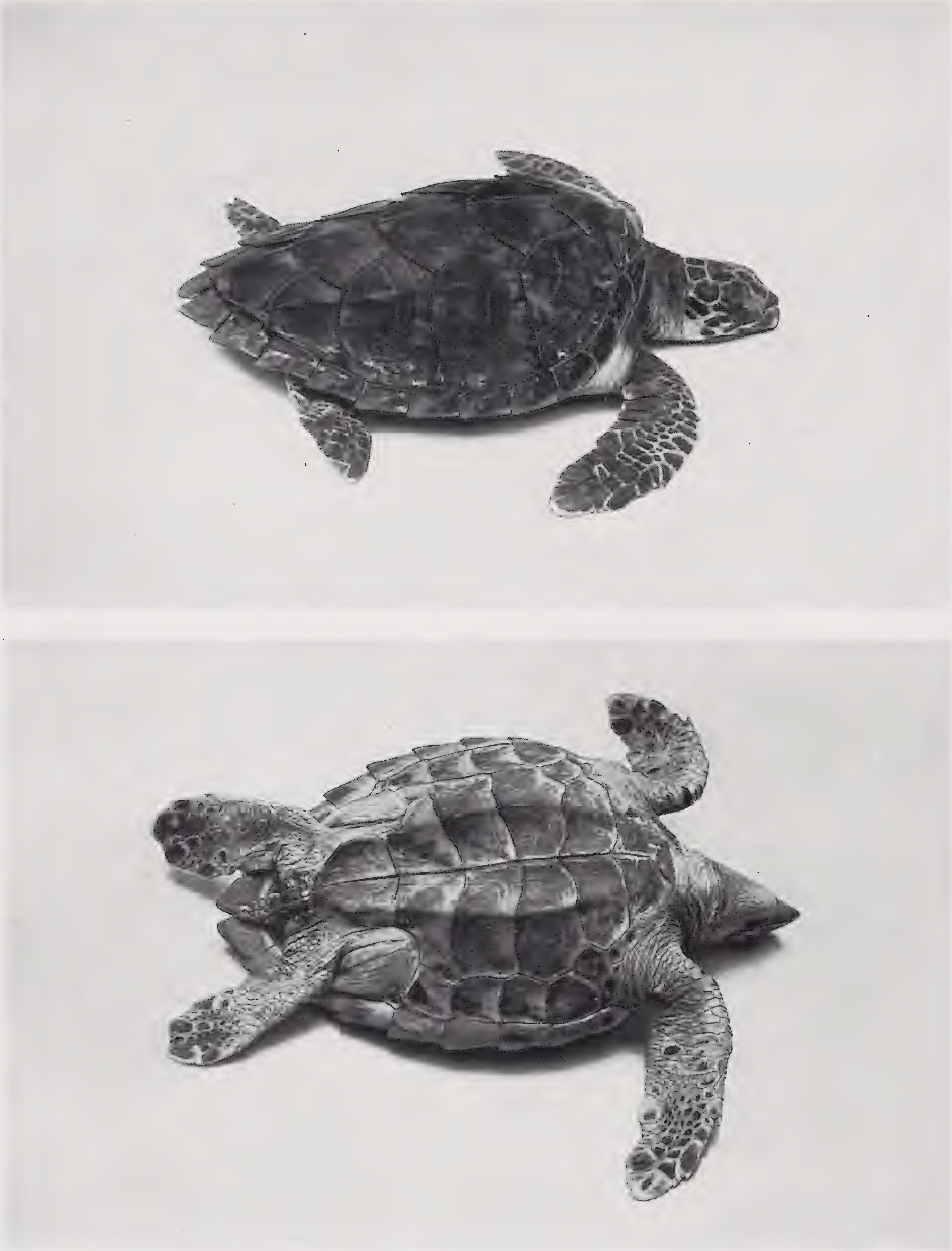


Fig. 5. Hawkbill Turtle, *Eretmochelys imbricata*. The tortoise-shell turtle, prized for many thousands of years, is represented in the upper and lower views. The over-lapping plates of the upper shell make the better grades of the tortoise-shell of commerce, while the clear and less clouded shields of the ventral surface are used as filler and where an inferior product can be substituted. Like other sea turtles the hawkbill has a remarkable homing instinct; females return to the same beaches year after year at breeding time. The Florida Keys were once considered the finest fishery in the world for this species, but over-fishing has resulted in the collapse of the industry. A small quantity of shell is still imported from Cuba and Colombia and prices for articles made or encrusted with it are prohibitive in price.

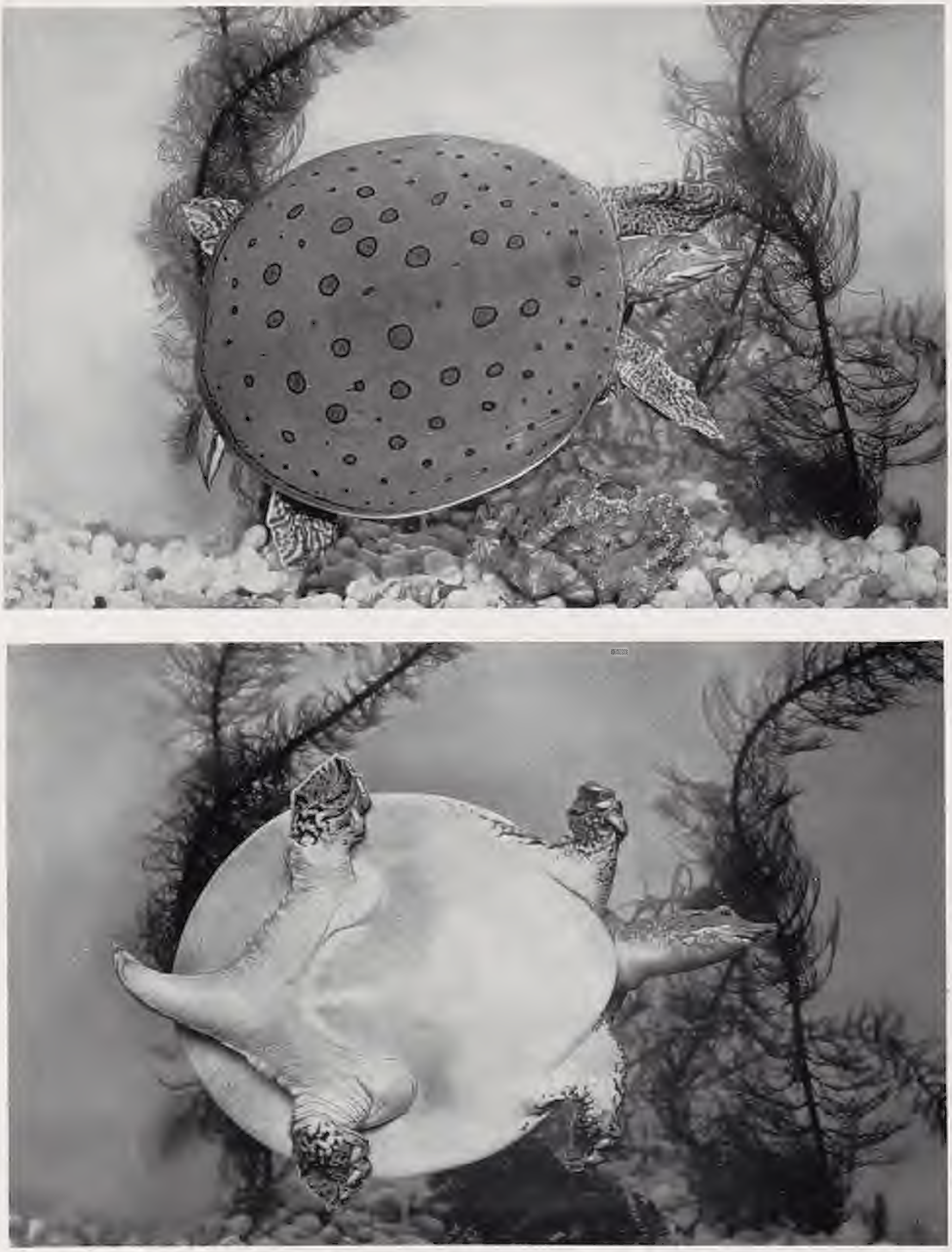


Fig. 6. Spiny Soft-shelled Terrapin, *Amyda spinifer*. Dorsal and ventral views of one of nature's anomalies—a terrapin without a shell. Like a somewhat related form, the trunk-back turtle, the spiny soft-shell terrapin is devoid of bony shields; even its jaws are sheathed in a fleshy covering. The under-lying bony structure with sparsely developed and widely separated parts in no way resembles the highly organized and closely knit skeleton of other chelonians. Caution must be observed in handling soft-shells.

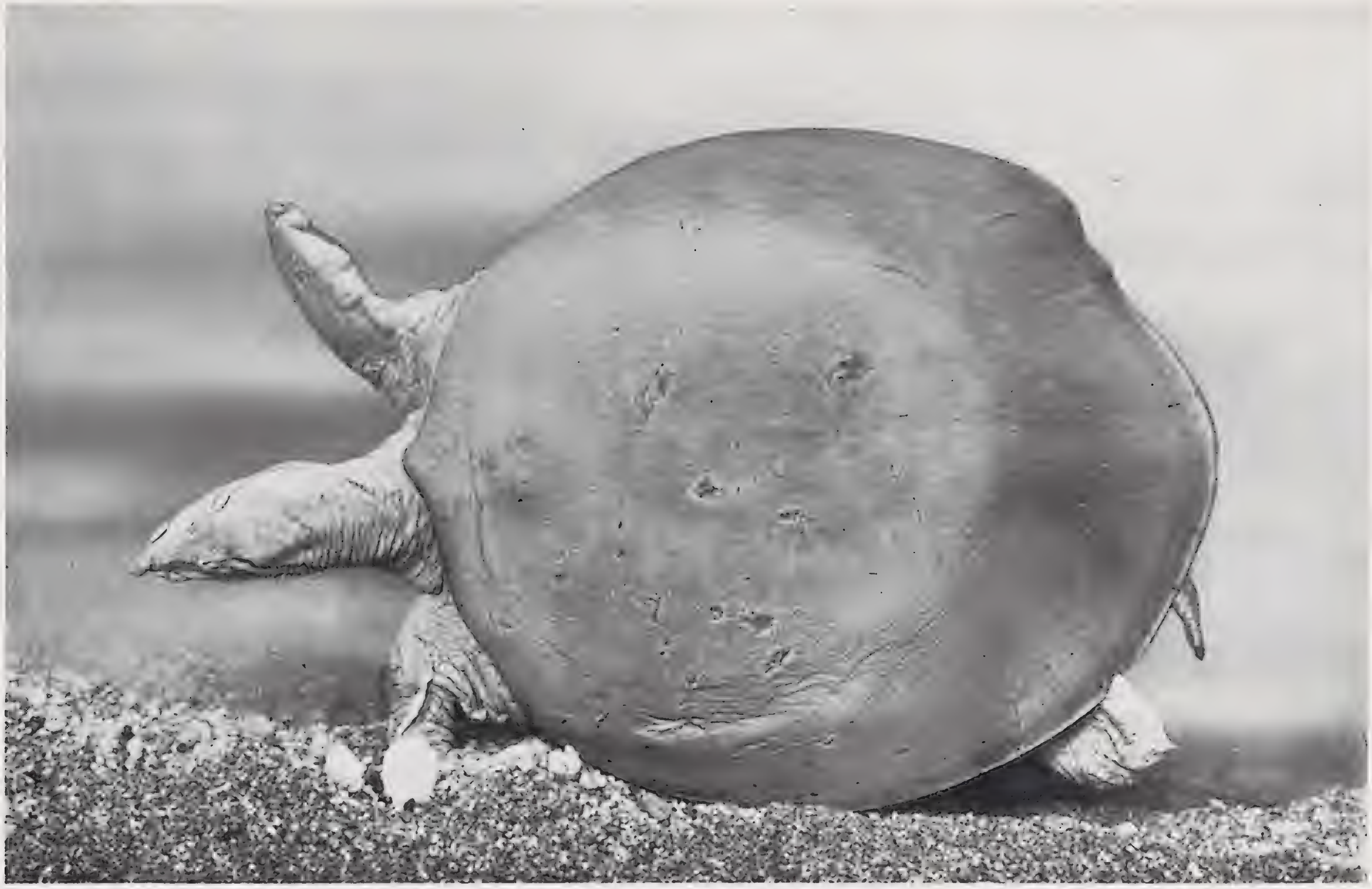
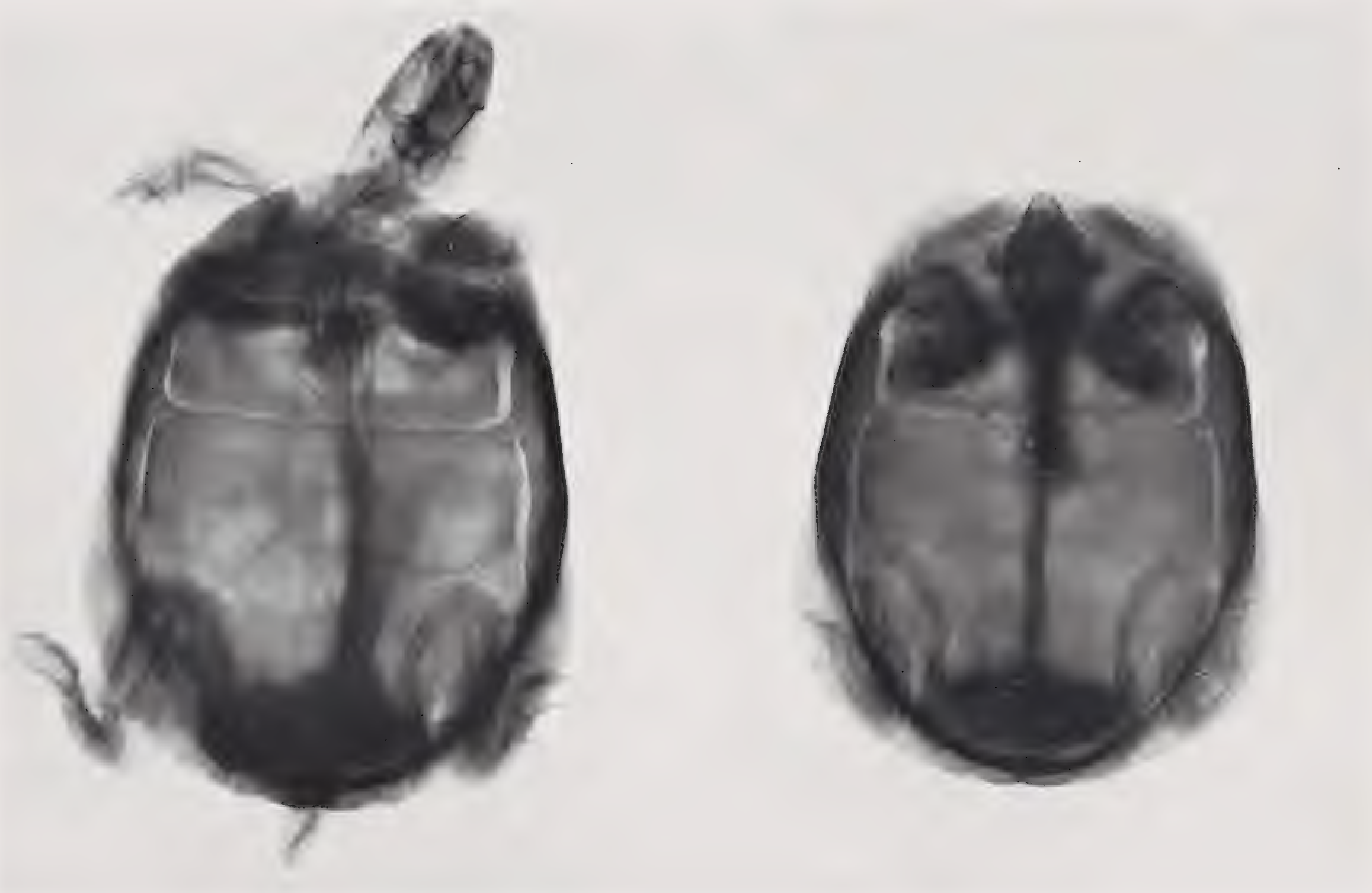
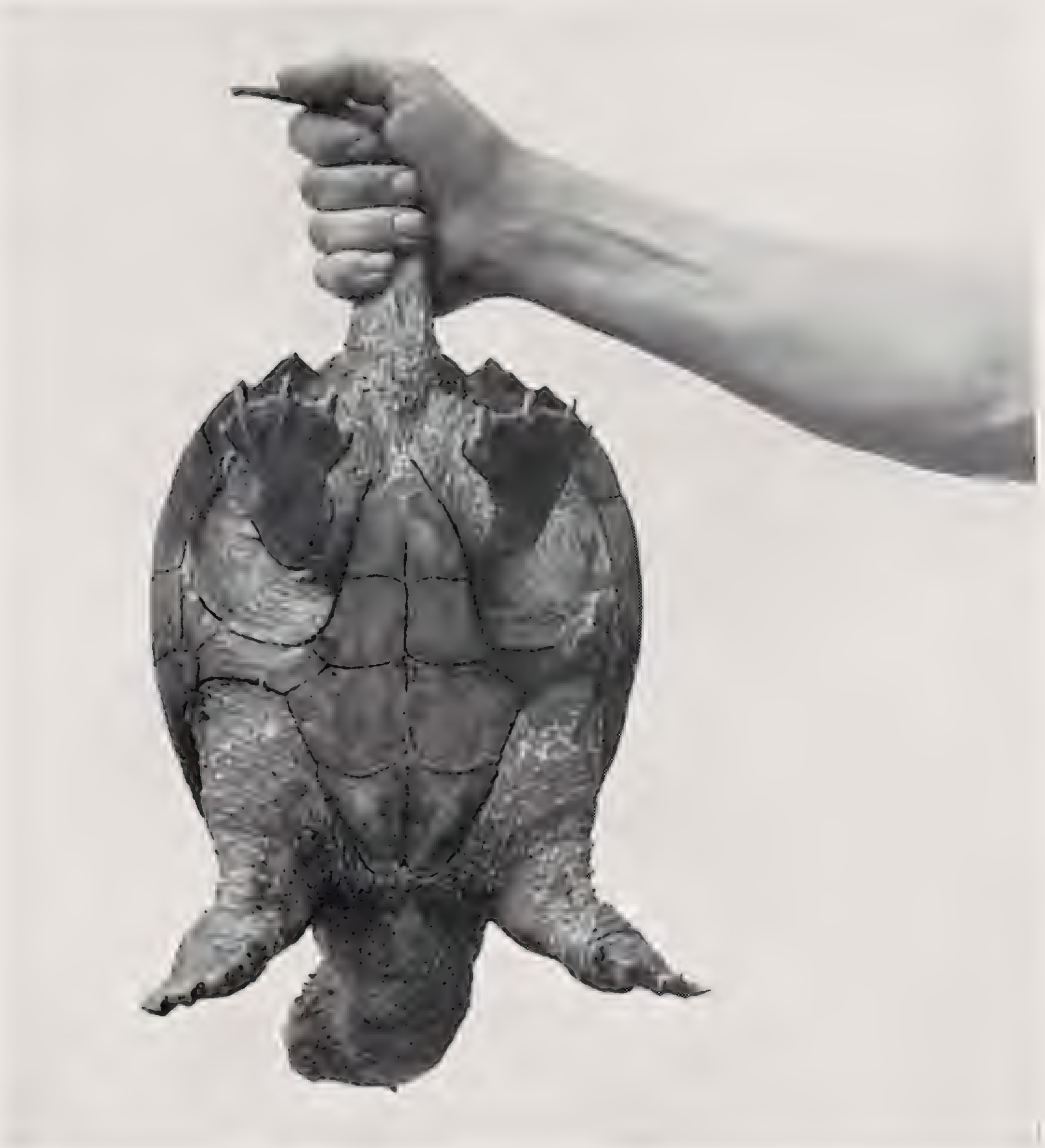


Fig. 7. Soft-shell Terrapin, *Amyda mutica*. Upper view of a soft-shell terrapin found through western New York State and Pennsylvania in the tributaries of the St. Lawrence River and in the Erie Canal. Like the spiny soft-shell, this species is both voracious in appetite and vicious in manner of attack.



Radiographs of the Box Terrapin, *Terrapene carolina*. The radiograph on the left of the page is an anterior-posterior exposure showing the extended limbs and head, as well as the pectoral and pelvic girdles reminiscent of human shoulder and hip bones. The other view, with head and neck retracted, illustrates the remarkable protection afforded by the bony shell. This shell is made up of ribs fused together. The center longitudinal line of the picture represents the back bone; the little bones, issuing at regular intervals from each side of the vetebral segments, are the beginning of the ribs. These ribs fuse together to form the bony, box-like covering of the animal. Radiographs taken at the Broad Street Hospital through the courtesy of Drs. Nahon and La Corte.



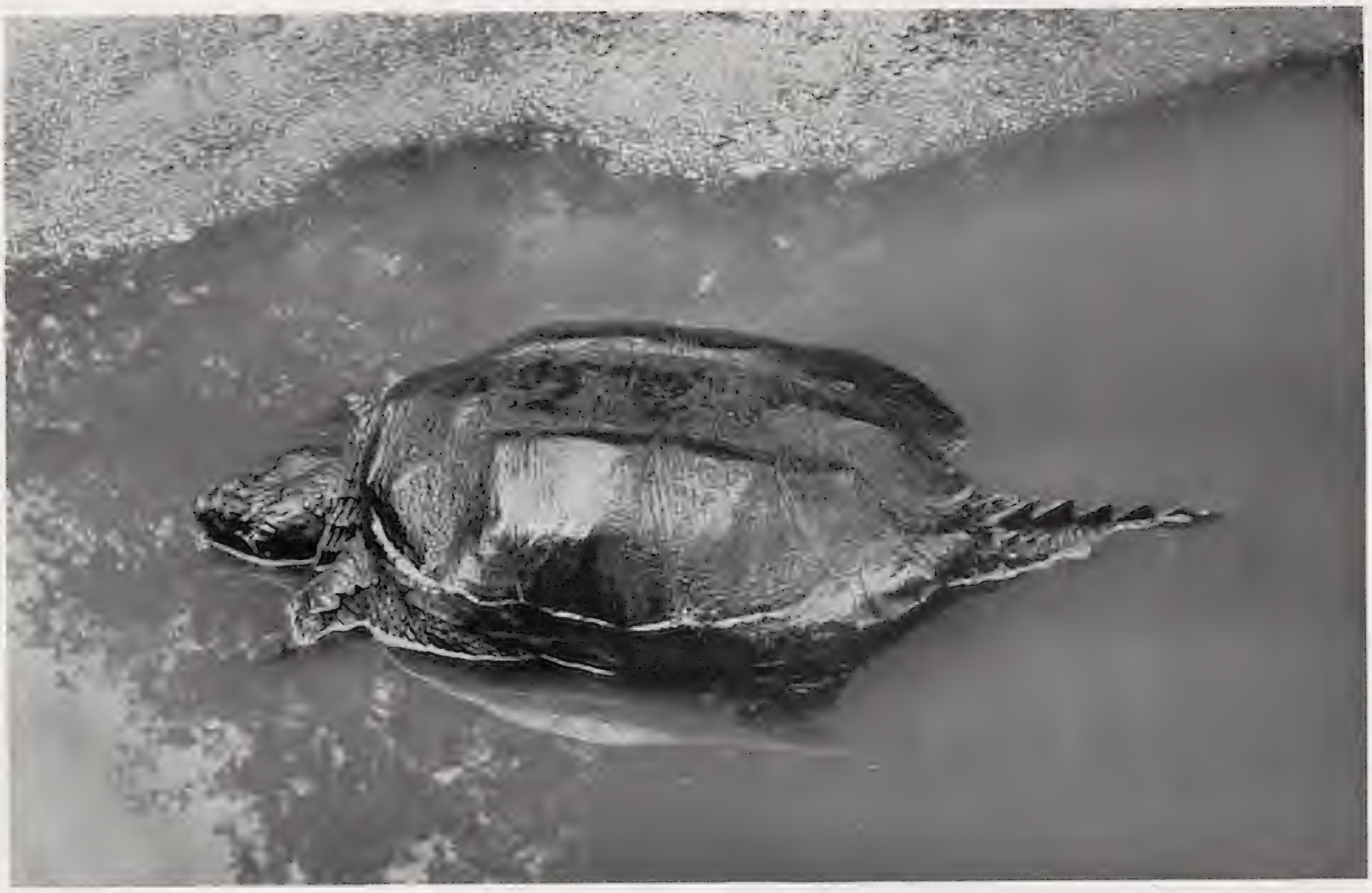
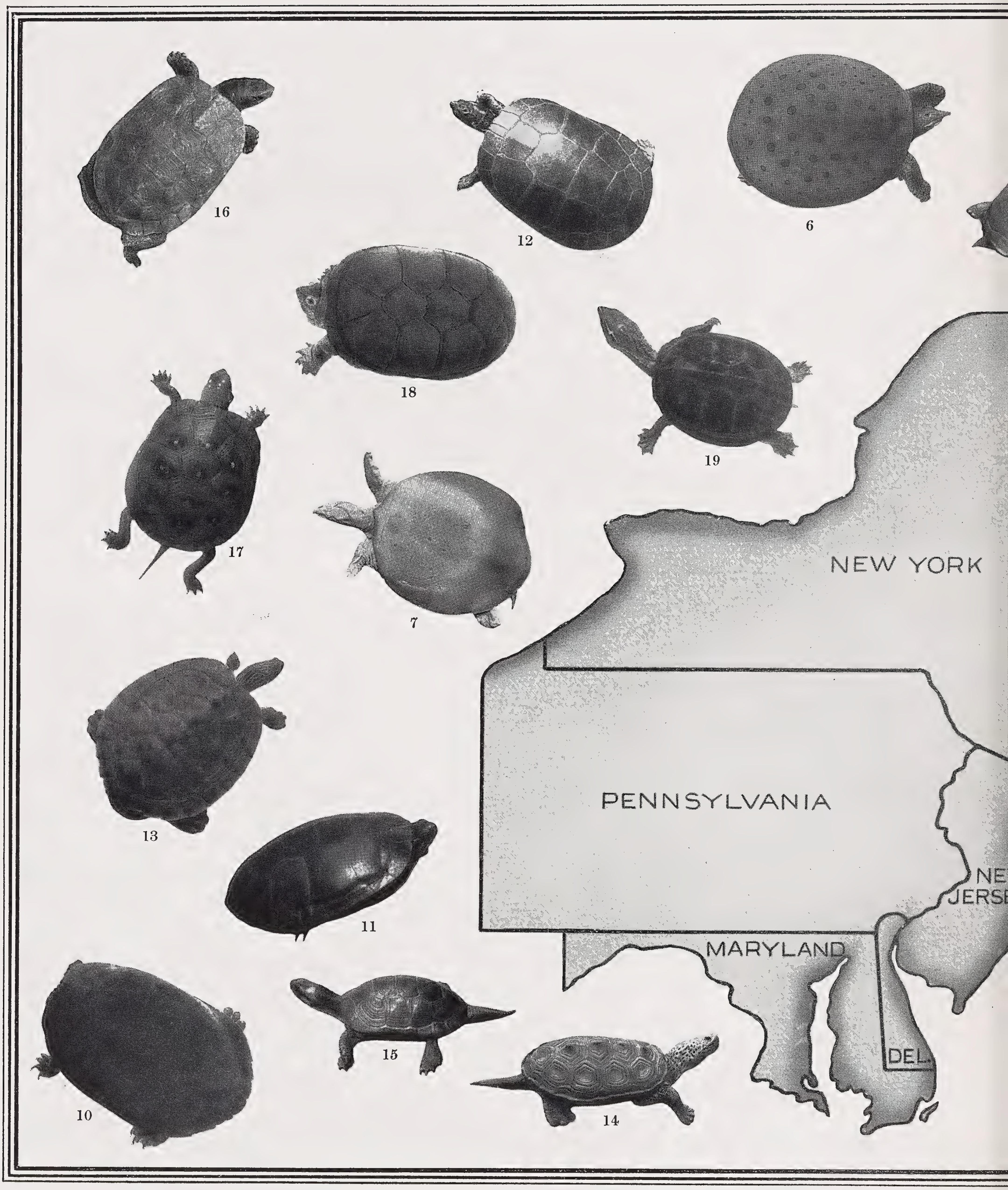


Fig. 8. Snapping Terrapin, *Chelydra serpentina.* The snapping terrapin is by far the most powerful and dangerous creature treated upon in this article. The photograph of its ventral surface shows the only manner in which this species may be safely handled. For this photograph, the terrapin was held by the tail and extended away from the body of its captor. Snappers are best in the soup pot, as they wreak havoc in many ponds and streams where water-fowl and game fish abide.



DISTRIBUTION OF TURTLES FO

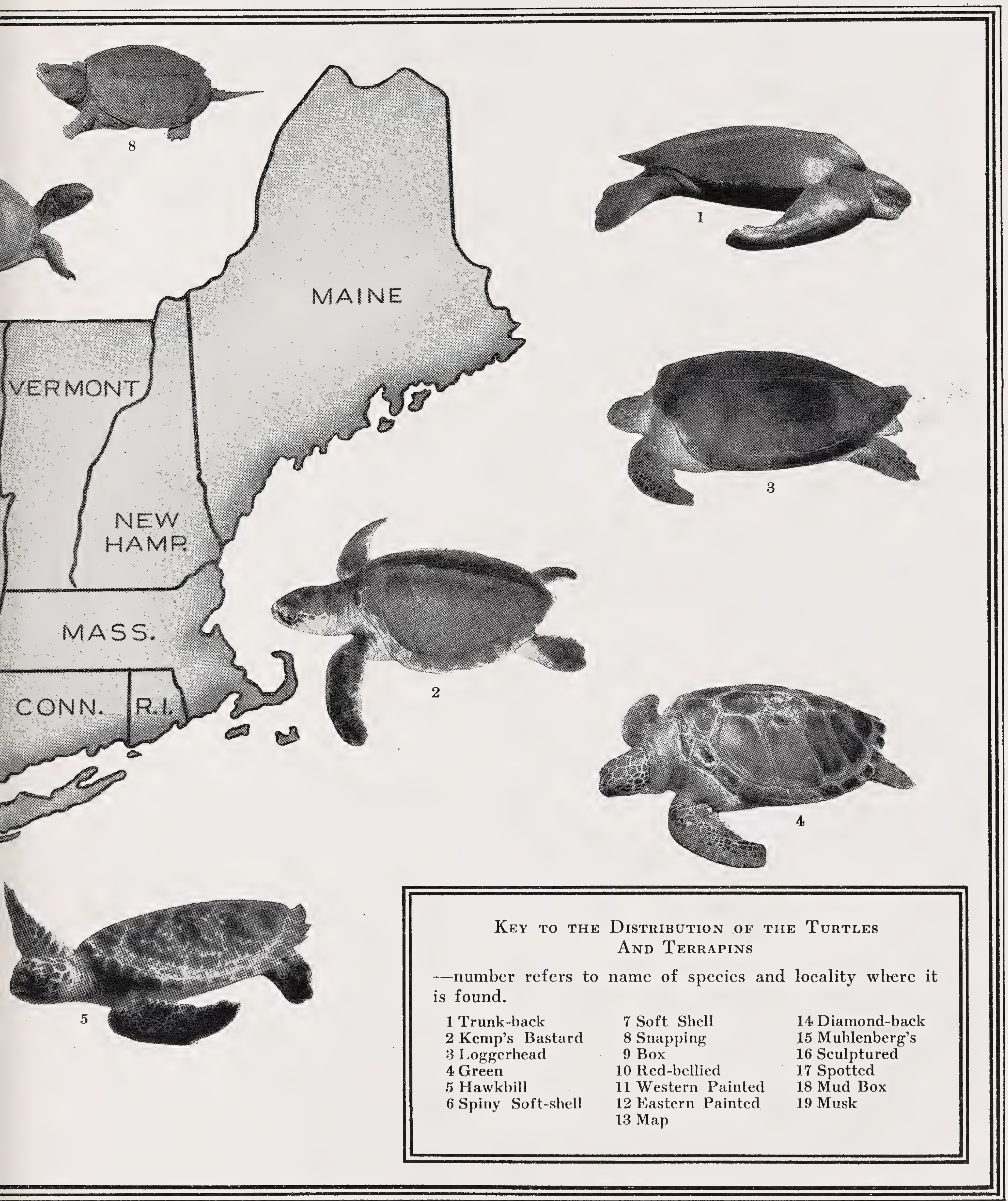
Attention is called to the figures of turtles bordering the map of the north-eastern coastal plain. Each turtles figured is named and numbered; the number corresponding to its location on the map shown and to the following explanatory notes.

Turtles 1 to 5 inclusive are taken from the coastal states only, as they are Sea Turtles.

The following turtles appear in equal abundance over the entire area shown on the map:—6, 8, 9, 10, 12, 13, 16, 17, 18, and 19.

The distribution of the foregoing species is widespread.

N. B.—The turtles shown are not reproduced in



Key to the Distribution of the Turtles And Terrapins

—number refers to name of species and locality where it is found.

1 Trunk-back
2 Kemp's Bastard
3 Loggerhead
4 Green
5 Hawkbill
6 Spiny Soft-shell
7 Soft Shell
8 Snapping
9 Box
10 Red-bellied
11 Western Painted
12 Eastern Painted
13 Map
14 Diamond-back
15 Muhlenberg's
16 Sculptured
17 Spotted
18 Mud Box
19 Musk

THE NORTH-EASTERN STATES

The following turtles do not occur in Maryland or Delaware:—6, 11, 13 and 15. Delaware also is lacking in number 7.

Number 11 is restricted to northern New Jersey, western Pennsylvania and western New York, while number 7 is found on the western border of Pennsylvania and New York.

Number 14 is peculiar to salt marshes and occurs in favorable parts of the coast. and northern New Jersey.

Number 15 is confined to southern Rhode Island, south-eastern New York, eastern Pennsylvania merely serve as a key for general identification.

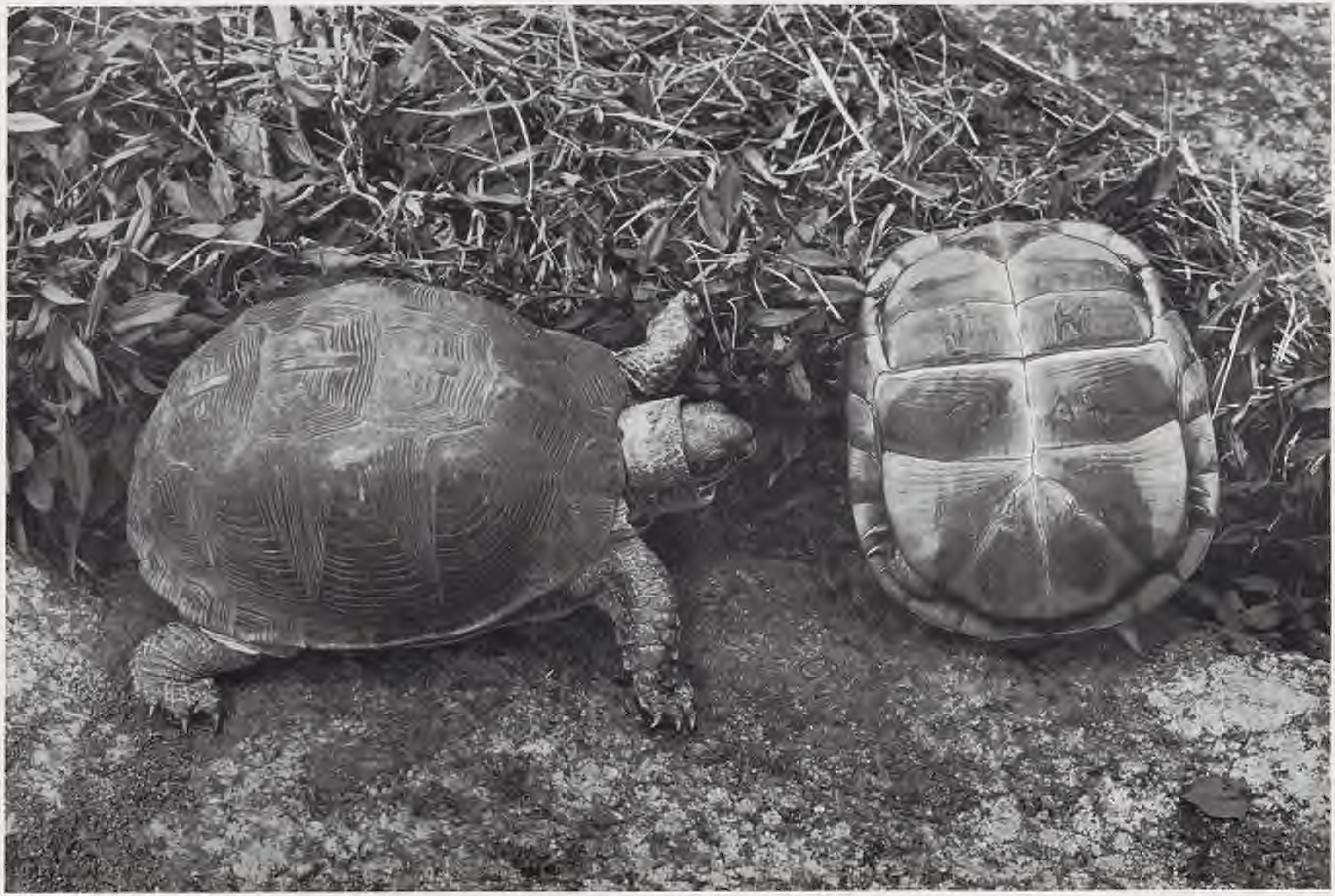


Fig. 9. Box Terrapin, *Terrapene carolina*. Tortoise-like in appearance, this attractive terrapin represents a transitional stage intermediate between terrestrial tortoises and aquatic terrapins. Along with the painted terrapin it is the commonest species of the eastern United States. Box terrapins are noted for their fearless attitude towards man and lend themselves to rapid domestication. The color pattern of the species undergoes great individual variation, ranging from bright lemon-yellow to deep orange-red.

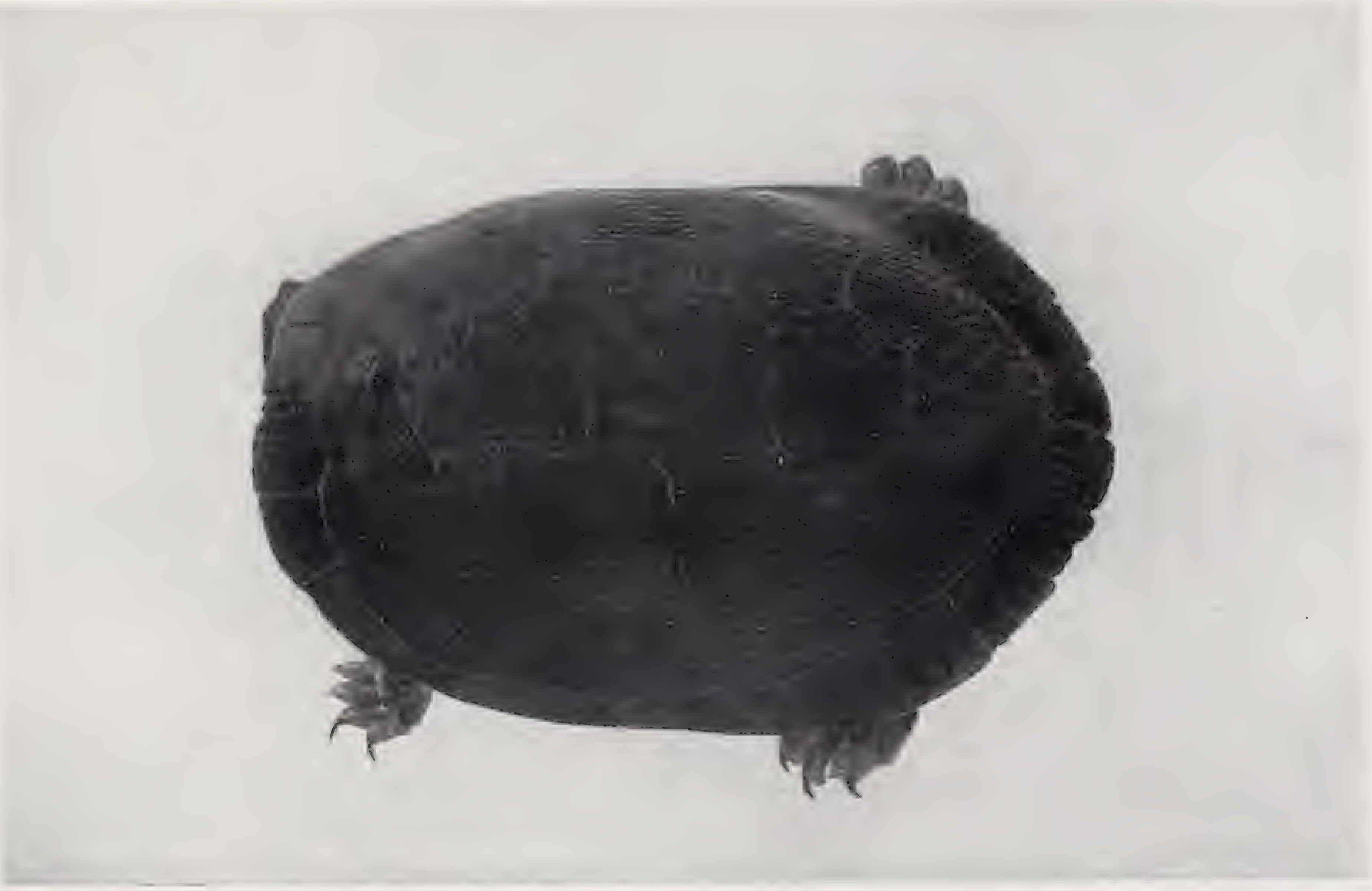


Fig. 10. Red-bellied Terrapin, *Pseudemys rubriventris*. When seen in its natural state, the red-bellied terrapin forms a most attractive spot of rapidly moving form and color amidst the green pond vegetation and clear running water. In the ponds about Plymouth, Massachusetts, it is still common and is used by the natives as an article of food.

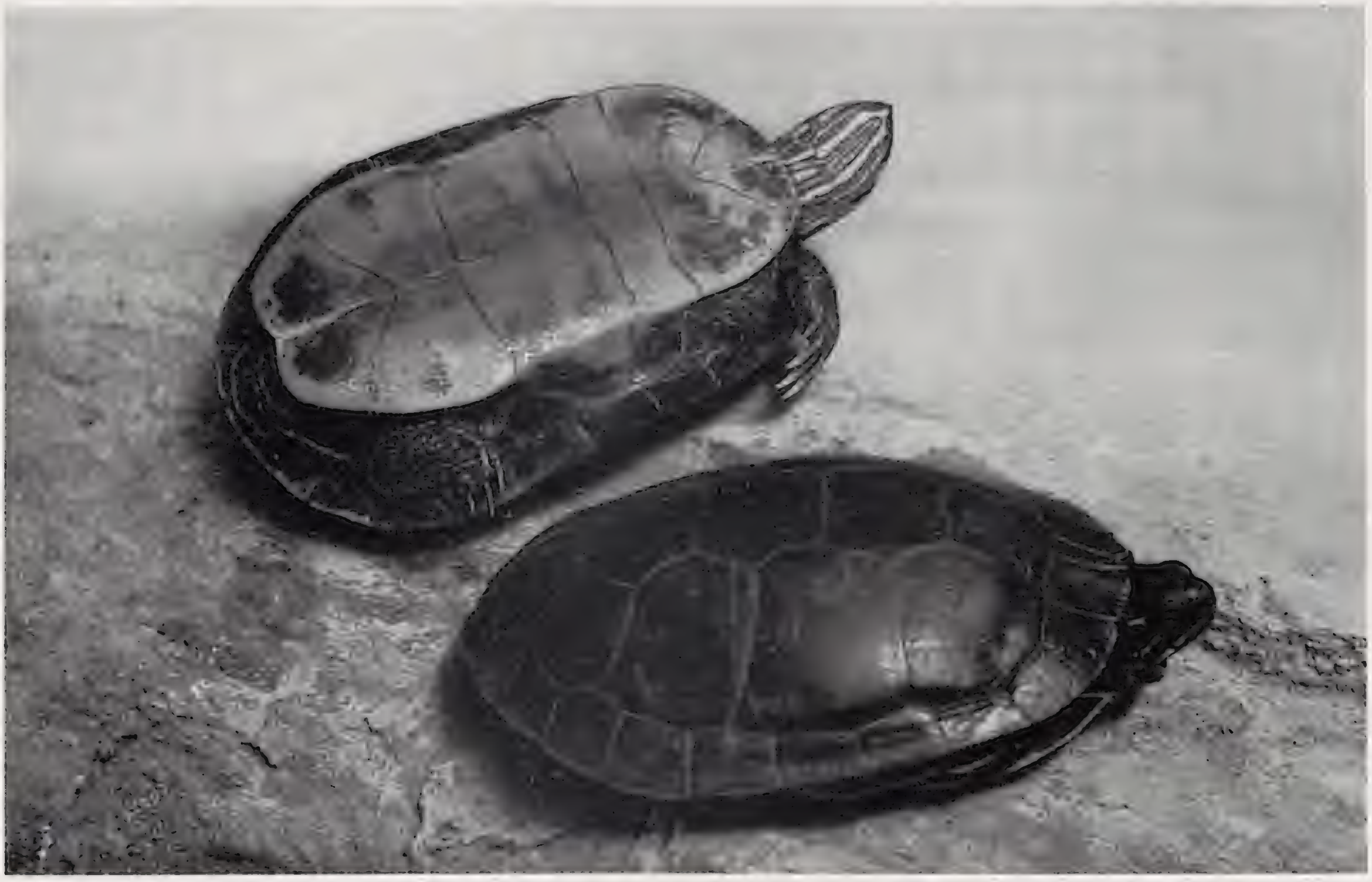


Fig. 11. Western Painted Terrapin, *Chrysemys marginata*. The palm for beauty is surely awarded to the painted terrapins. Their vividly contrasting colors set them apart from all other terrapins. The marginal shields are delicately splashed with red, while the plastron is a golden yellow, sharply defined from the deep brown olivaceous color of the carapace. In the western species the plastron is marked with a dark ovoid patch and the carapace has a pattern outline, as shown in the drawing following the key to identification. Photograph by Dr. R. L. Ditmars.

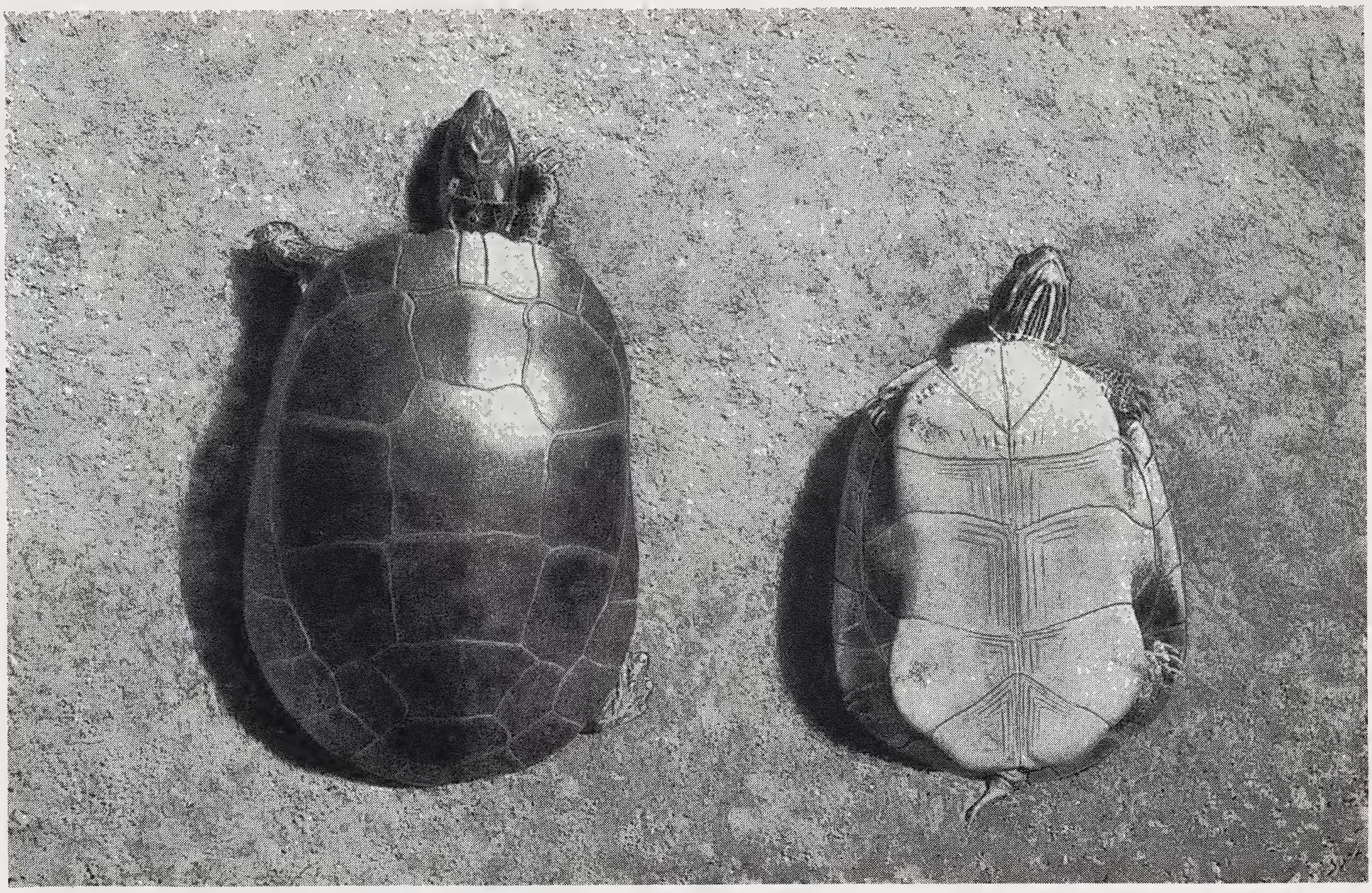


Fig. 12. Eastern Painted Terrapin, *Chrysemys picta.* A species closely allied to the form found in the westerly portions of the terrain under consideration but differentiated from it, as may be seen in the photograph, by a plastron of immaculate yellow. This painted terrapin is the species most commonly found in this locality. Specimens can be seen in almost every pond and lake of the Atlantic coastal plain and are familiar to anyone who has occasion to be in the country.

and feeding habits of the species are similar to those of the green turtle. Many observations have been made of the loggerhead as it lays its eggs along the coasts of Florida, Georgia, the Carolinas and sometimes as far north as Virginia. The loggerhead is a strong swimmer carrying its fore flippers well elevated, in a manner simulating the wings of a bird. Its flesh is often substituted for that of the green turtle. Ditmars says of its habits ashore:

> To discover one of these sea monsters on the beach is to experience a certain feeling of awe. The great, floundering brute, in the fulfillment of parental duties, is practically at man's mercy, yet clumsily alert. It suddenly exhales the breath with a deep, roaring sound, while the bleary, seal-like eyes stare in a seemingly vacant fashion. If a big conch shell is shoved within reach of the jaws, it is seized and crushed in a single grasp. Turned on its back, the giant is helpless. If not hindered it makes for the sea, causing a great commotion in reaching the water, as it flounders for sufficient depth where it may find purchase for the paddle-like fins.

THE GREEN TURTLE, *Chelonia mydas* (Linne), Fig. 4. The Green Turtle is valued for its succulent flesh, being the delight of epicures and the substance of green turtle soup and turtle steak. Specimens brought to market from West Indian and Florida waters weigh about fifty pounds and command fancy prices. The species is found in all warm seas and is carried to our coasts by the Gulf Stream, a warm body of moving water that is responsible for the occurrence of many tropical forms taken along northern shores.

Size and Color: The decimation in recent years of this species so highly prized for its flesh has resulted in a decrease of the figures given for size and weight. Six foot specimens were common in the past but today the average length is about three feet. The body is olive-brown above and mottled with yellow. The plastron is yellow.

Habits and Economic Use: During the course of the breeding season (April to June in the Bahamas) the female turtle crawls out on the sand above tide line and digs a hole about two feet deep, using her hind flippers as scoops. She lays between one hundred to two hundred eggs which are carefully arranged in the nest. She then smooths the loose sand over the hole and so skillfully levels the beach surface that no trace of the nest can be seen. The nest is

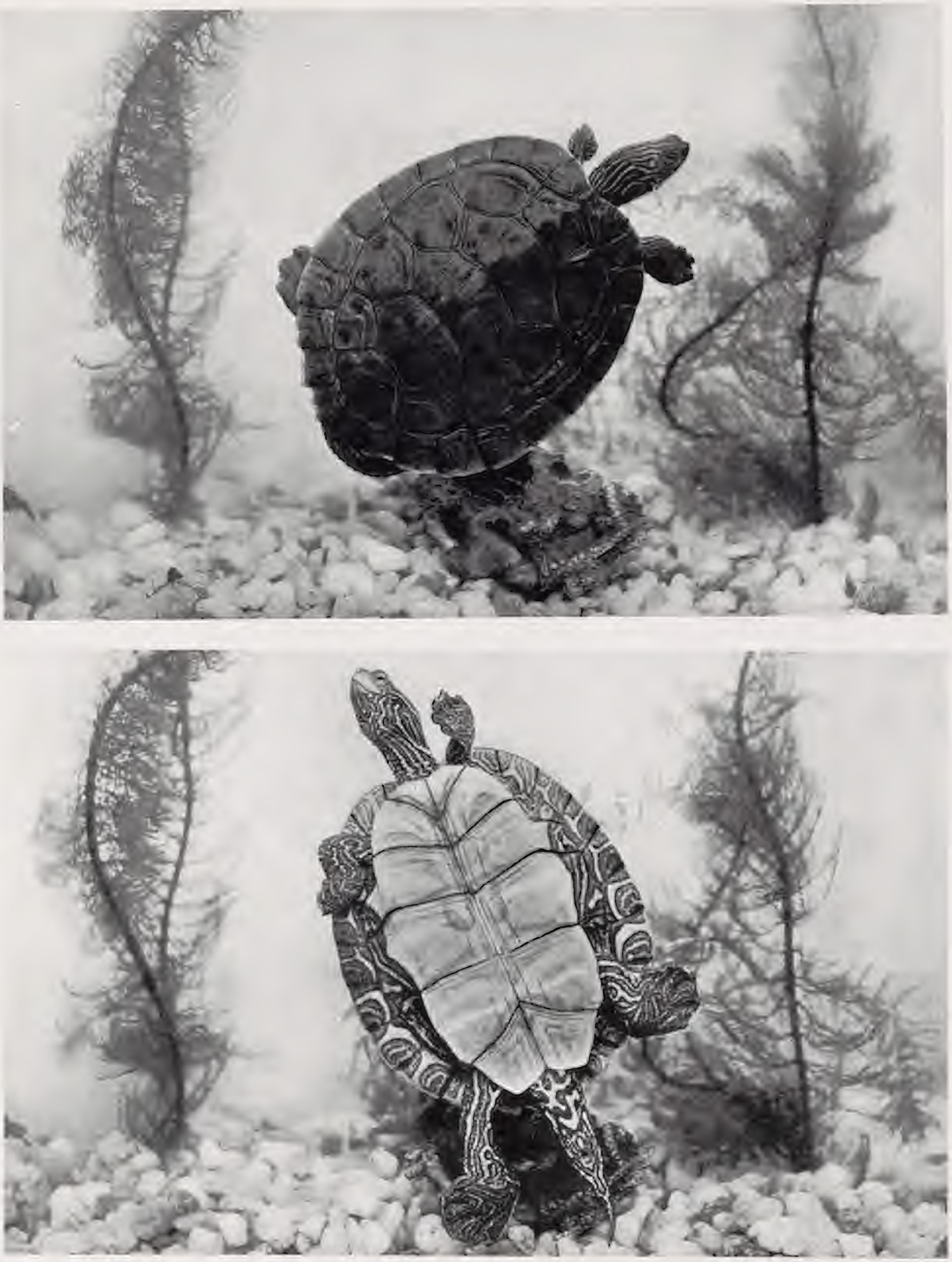


Fig. 13. Map Terrapin, *Graptemys geographica.* Evenly distributed over the entire area considered in this article, this attractively figured terrapin passes in pet shops as the "Japanese Turtle." In its natural habitat it prefers shallow soft-bottomed ponds, but if fed on raw beef (not ant eggs) and kept in a warm, moist terrarium with some water for swimming and drinking purposes. It will attain a size of half a foot or more at maturity. It seems unable, like all fresh-water terrapins, to eat unless under water. Like the red-bellied terrapin, it is edible.

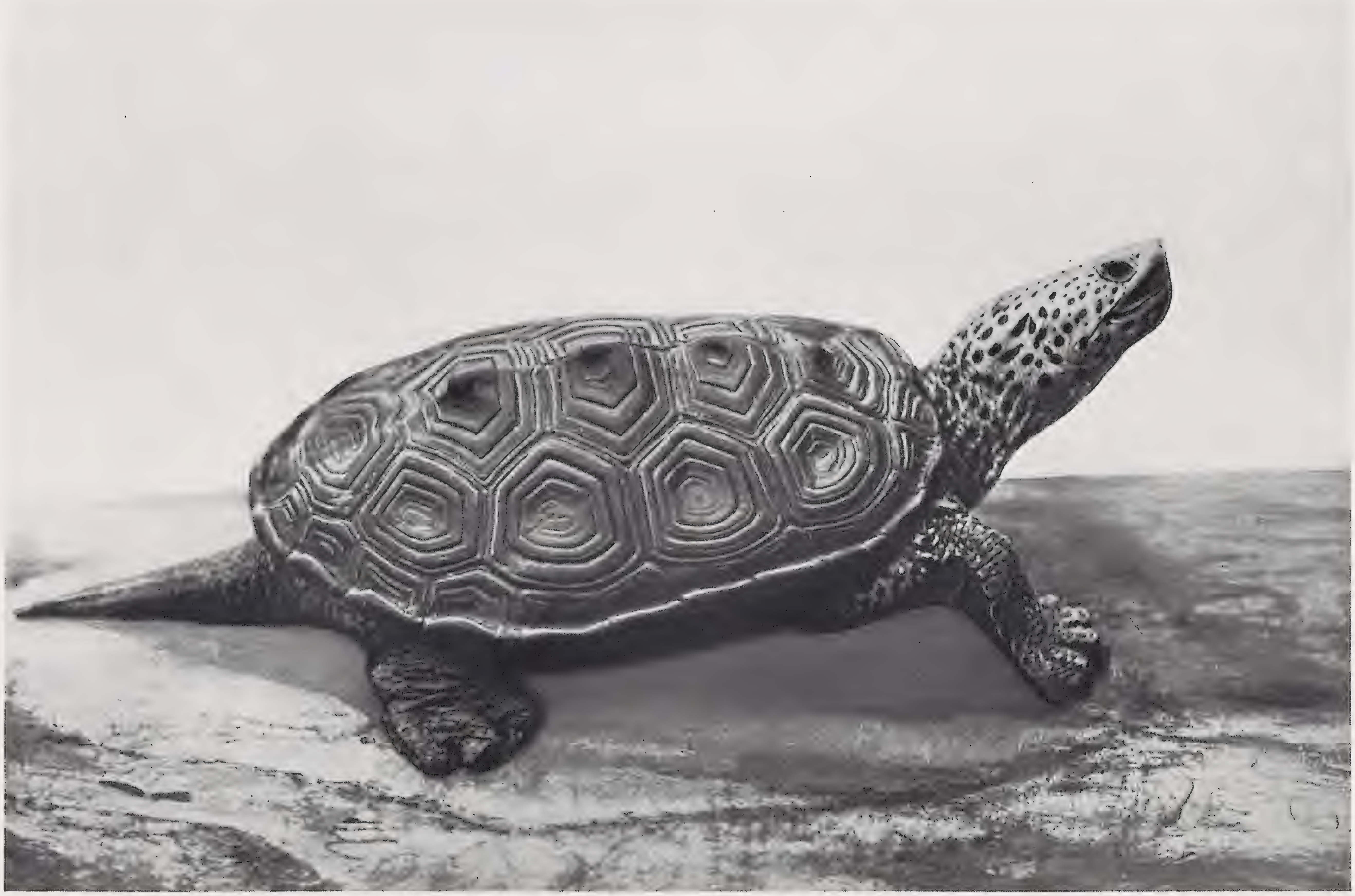


Fig. 14. Diamond-back Terrapin, *Malaclemys centrata concentrica*. From an economic and a gastronomic standpoint the diamond-back terrapin is our most valuable reptile. The photograph reproduced above is an excellent study showing many salient points of interest. The photographs on the opposite page give some idea of governmental efforts in developing methods to repropagate the species. Photograph made in the New York Aquarium by the late Leonard B. Spencer.

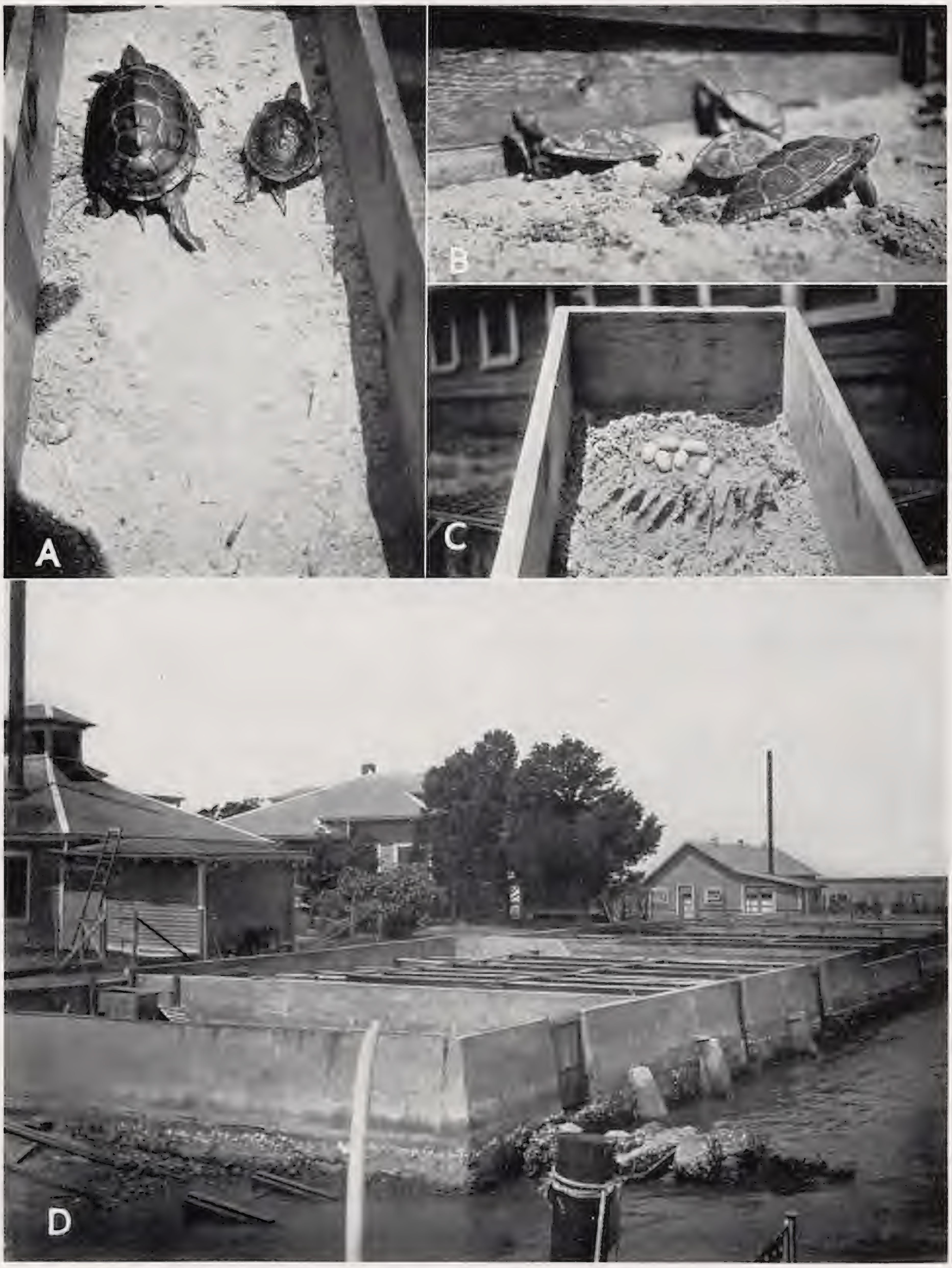


Fig. 14a. Diamond-back Terrapin, male and female. A marked difference in the size of the sexes is shown in this view. The male is much smaller than the female and consequently less valuable as food. Commercial hatcheries are acquainted with this fact and achieve good results by placing one male with every fifteen female terrapins. Fig. 14b. Diamond-back Terrapin on nest. The females shown are engaged in depositing their eggs in the loose and moist sandy beds provided for egg laying. Fig. 14c. Diamond-back Terrapin eggs. An uncovered egg clutch laid by one female terrapin at the Bureau of Fisheries hatchery. Fig. 14d. Diamond-back Terrapin pens at Beaufort, North Carolina. The terrapin pens are shown at high tide. The beds of sand are banked so as to make laying spaces as well as pools in which food is eaten and where the terrapins "crawl" for the best part of the time. The change in tide either floods part of the crawls with clean sea water or drains off the accumulated filth depending on whether the tide is high or low.

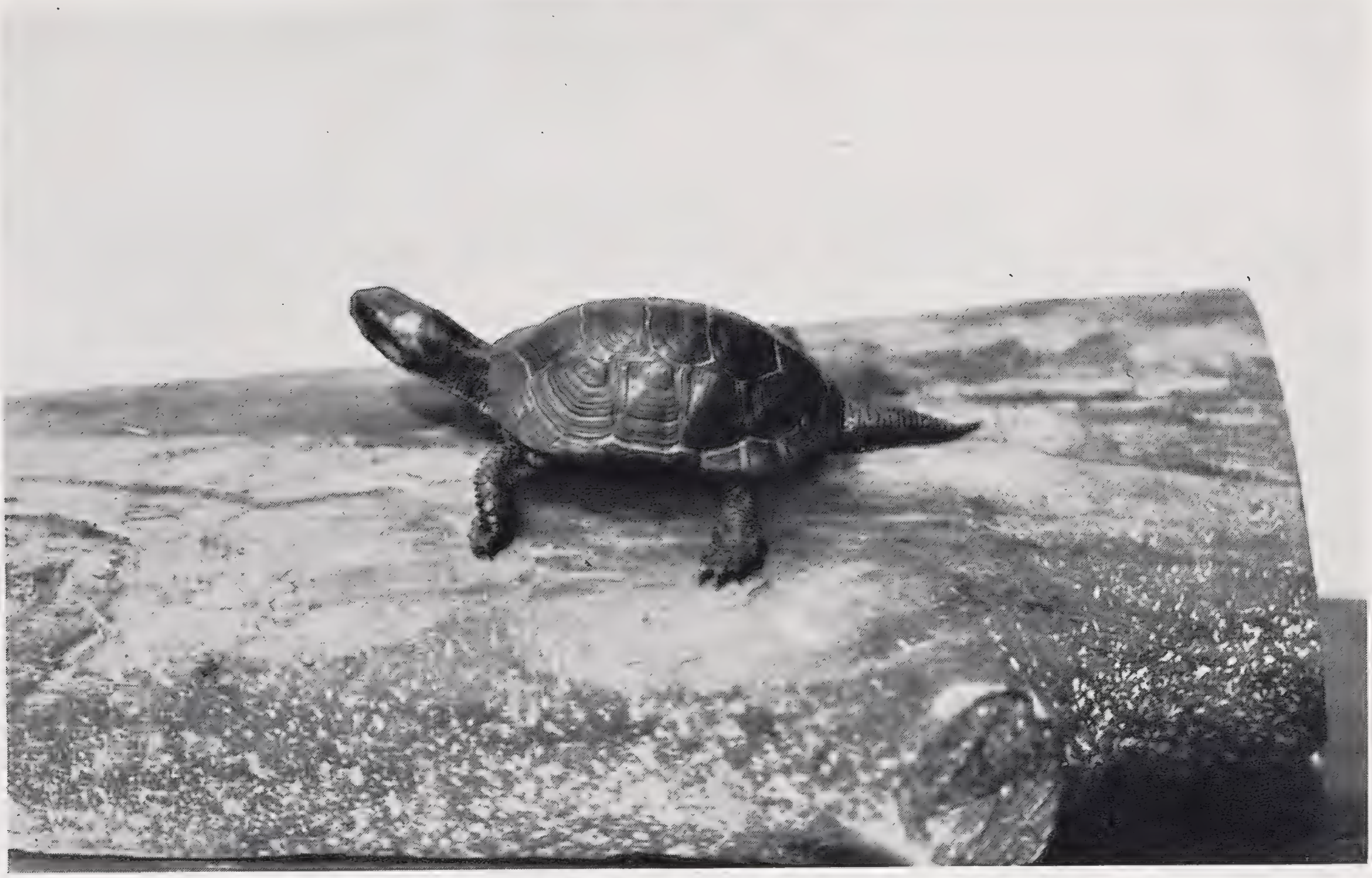


Fig. 15. Muhlenberg's Terrapin, *Clemmys muhlenbergi.* A rare and exotically marked wood terrapin peculiar to sphagnum swamps of southeastern New York, northern New Jersey and eastern Pennsylvania. A few specimens have been reported from Rhode Island. Land reclamation has laid toll to these creatures as in the case of the diamond-back. The brightly colored orange patches on the side of the neck at once distinguish this species from all others. Photograph made in the New York Aquarium by the late Leonard B. Spencer.

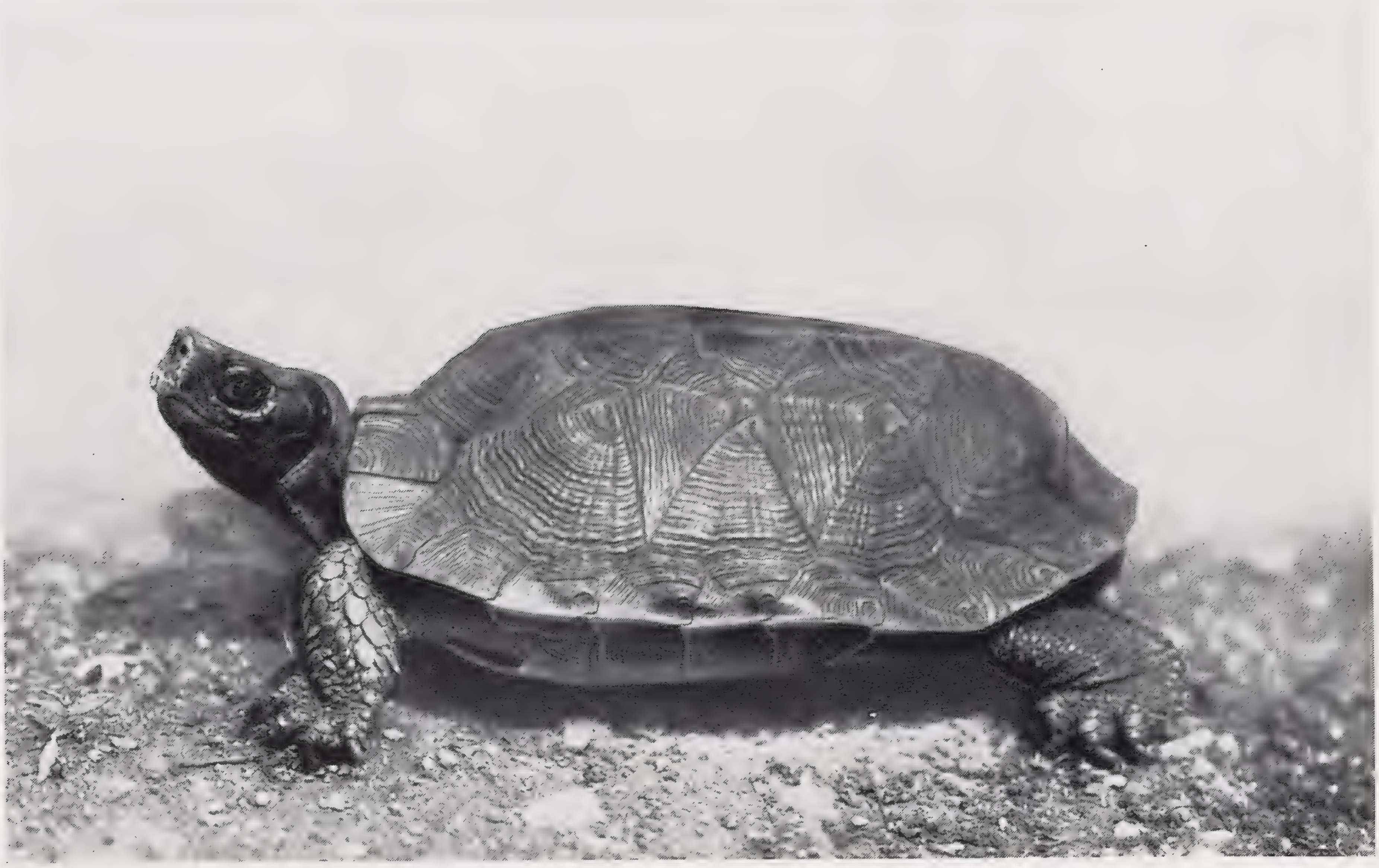
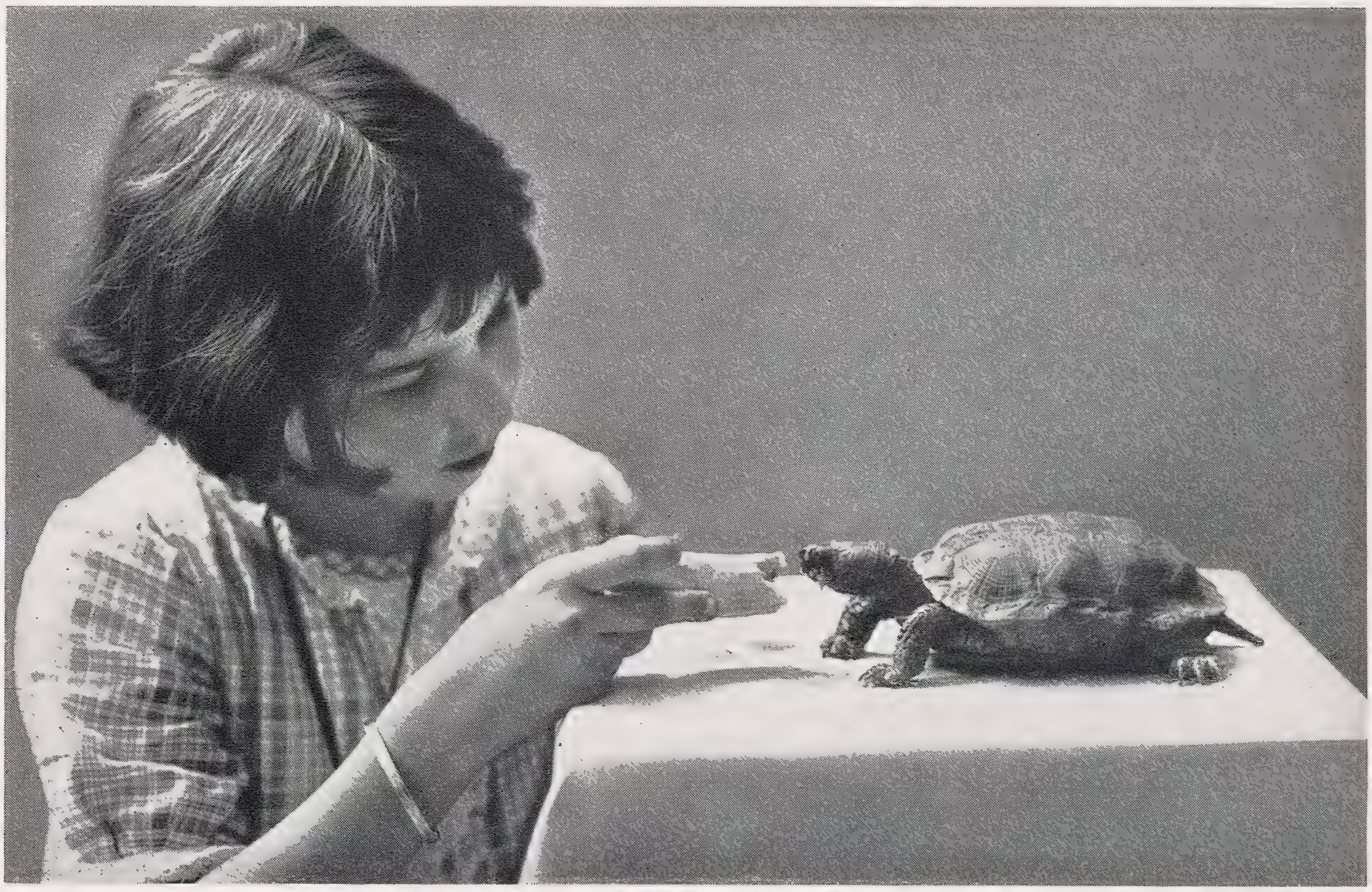


Fig. 16. Sculptured Terrapin, *Clemmys insculpta.* An upland wood terrapin noted for its remarkable tameness as well as its edible qualities. State legislation in New York and New Jersey protect the species from molestation and help to insure its existence. Experiments in turtle trailing at the Wyanokie Zoological Station of the New York Zoological Society tend to demonstrate its well-developed sense of direction.



This intimate photographic study depicts the remarkable tameness of the sculptured terrapin. Head Keeper Toomey's daughter is shown feeding a banana to her pet.

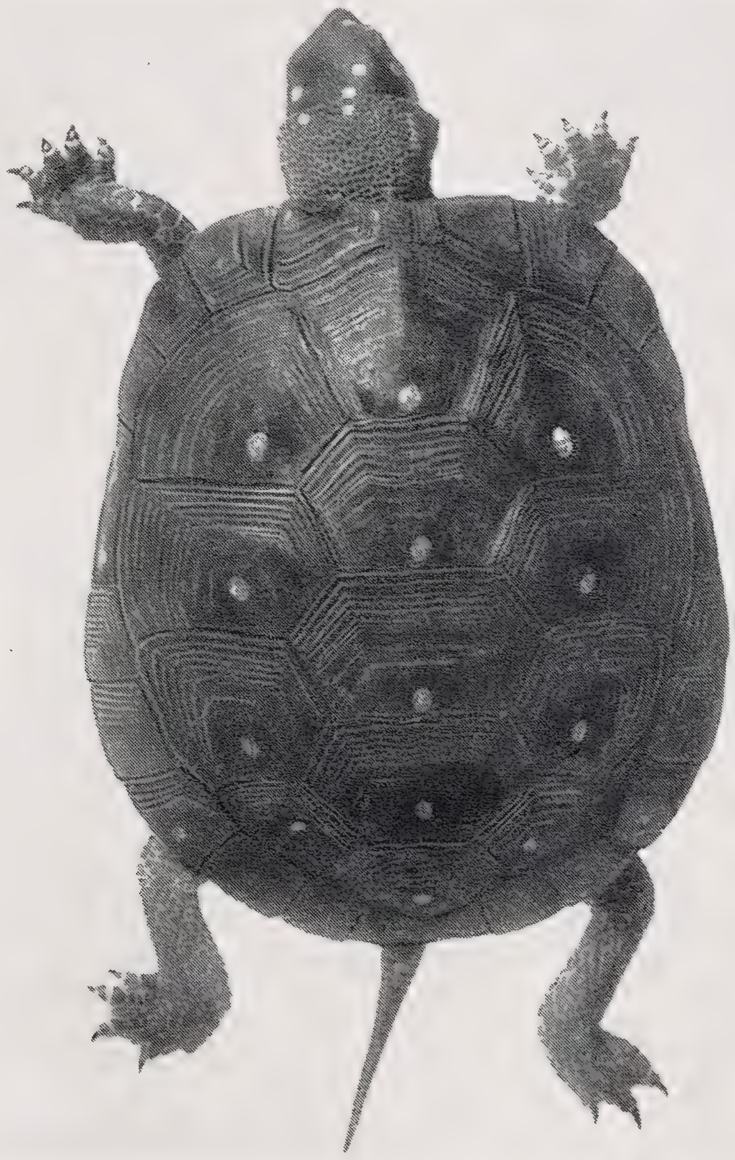


Fig. 17. Spotted Terrapin, *Clemmys guttata.* Closely allied to the Muhlenberg and sculptured wood terrapins this species exhibits no special characteristics. The bright yellow spots appearing on each black dorsal shield render it both conspicuous and pleasing to the eye of the observer. It feeds on frogs, toads, insects and dead fish. The wood terrapins are less aquatic in habit than the slider forms: painted, red-bellied and map terrapins indicating a semi-aquatic mode of life.

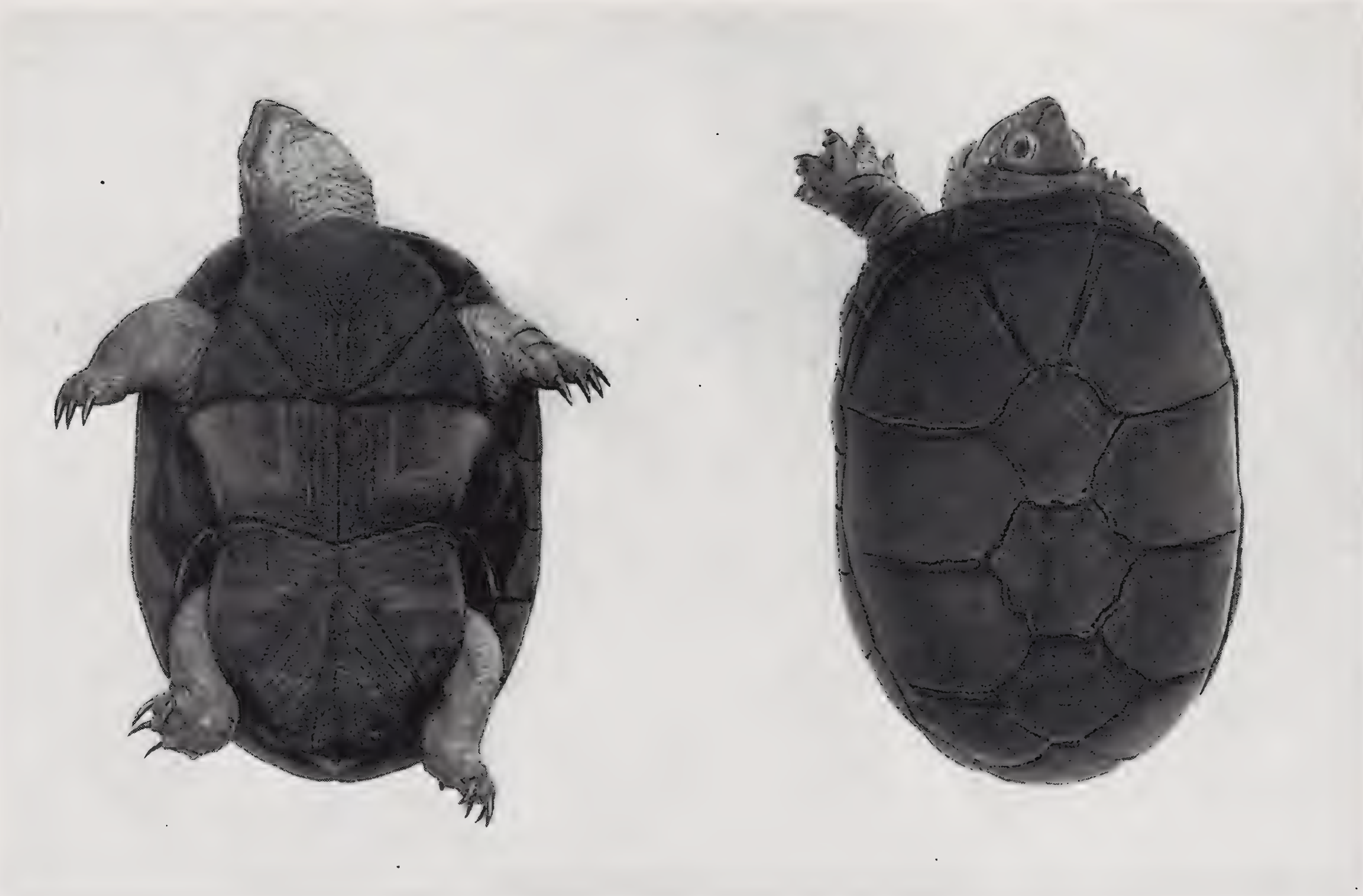


Fig. 18. Mud Box Terrapin, *Kinosternon subrubrum.* Well shielded above and double-hinged below, this mud terrapin is further protected by the possession of musk glands that exude a strong fetid odor when the animal is handled or pursued. The species is notable among reptiles in that the males have a sound-producing mechanism which they use to attract females during the mating season. By means of horny scales on the hinder limbs, stridulating sounds like the chirp of crickets are produced.

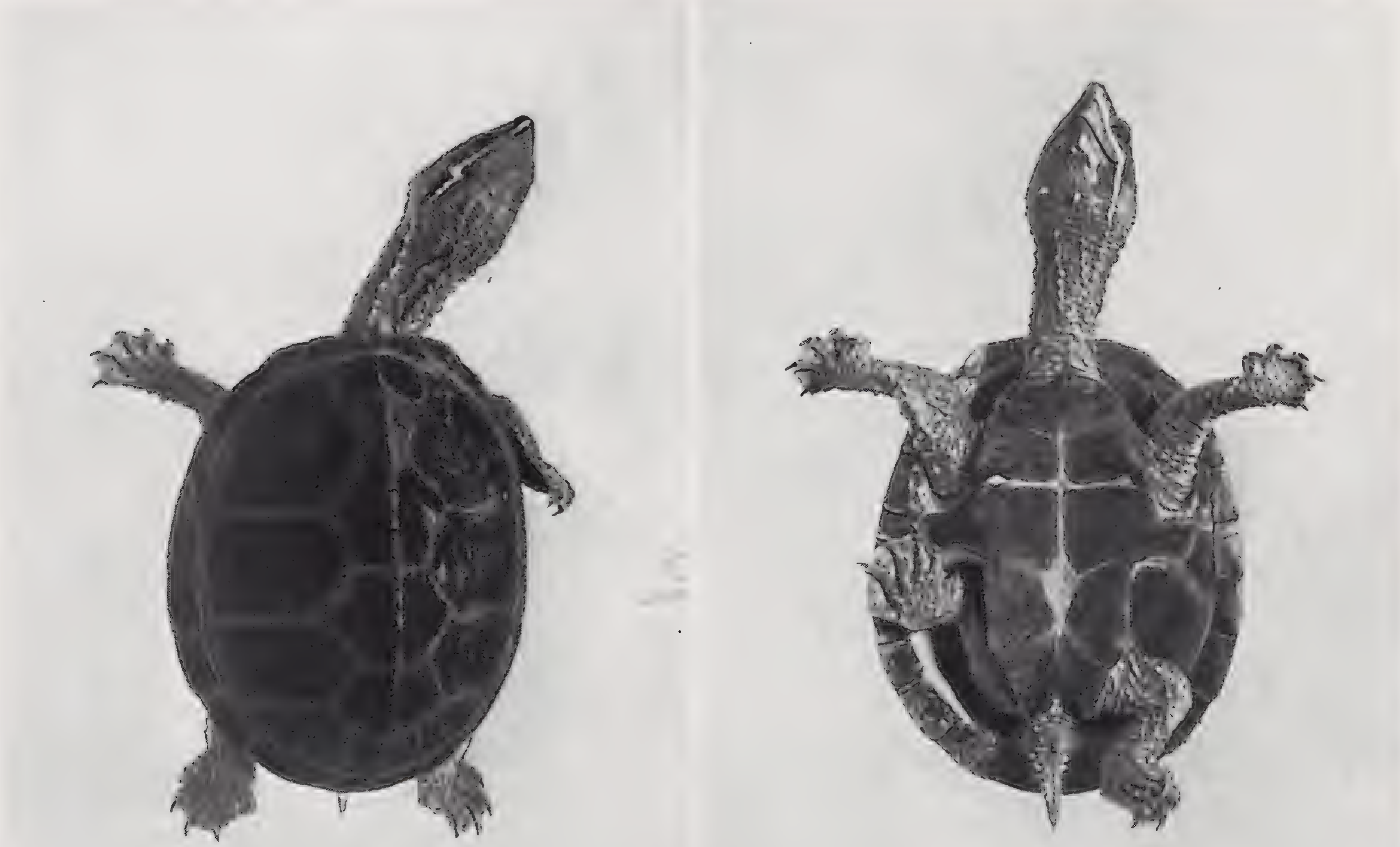


Fig. 19. Musk Terrapin, *Kinosternon oderatum.* As in the preceding species this terrapin is armed with a defense mechanism in the form of scent glands. It has been suggested that this odor may be used at the pairing season in much the same manner as crocodilians, who leave a scented wake through the water in order to attract members of the opposite sex. The musk terrapin is choleric of disposition and resembles the snapper in its manner of darting out an angry pair of snapping jaws in the direction of its captor. It inhabits the bottoms of muddy ponds and swamps.

not revisited, the eggs being incubated by the sun's warm rays. The young turtles have an egg tooth, a hook-like protuberance on their upper beak which enables them to break through the shell; and then digging their way out of the sand, they make for the water. However, sea birds are on the alert for these delicate morsels and only about thirty per cent of the turtles hatched have a chance to reach maturity. Fishermen prey upon the nests and remove the eggs which are sold for attractive figures, two dollars a pound being the current price at Key West, Florida. In the Pacific, off the coast of Panama, I have observed great numbers of these turtles feeding on patches of sea-weed. Marine plants such as turtle-grass (*Zostera marina*) and small crustaceans form the principal diet. The meat is prized the world over and a fine cosmetic oil is produced from the eggs.

THE HAWKBILL TURTLE, *Eretmochelys imbricata* (Linne), Fig. 5. The hawkbill turtle is the species that yields the valuable tortoise shell of commerce. This turtle has been pursued for hundreds of years and today it is a rare species with the price of articles made from the horny plates of its shell ranging from twenty-five to twenty-five hundred dollars. Craftsmen from before the time of Cellini to the present day have utilized this shell to produce articles ranging in size from the bath tub of the Emperor Nero to the expensive little cigarette case so valued by this generation.

Size and Color: Seldom over two feet in length. Body brown mottled with yellow above, and with clear yellow beneath.

Habits and Economic Use: Its feeding and breeding habits are similar to the green and loggerhead turtles. It is rare along our coasts, occurring only in mid-summer. The turtle is chiefly sought for the plates of the carapace, called "tortoise shell," which is much thicker, stronger, and deeply clouded with richer colors than those of any other species. On the south coast of Cuba I have observed fishermen catching these turtles with the remora or sucking-fish (*Echeneis naucrates*) to the tails of which they attach a line; the fish are thrown in the direction of the basking turtle, and seize on to its shell with their sucking-disc. The fishermen then pull up their turtle capture. The turtles are killed and left to rot on the open beach. When decomposition has set in sufficiently to loosen the epidermal plates, these are removed and immersed in vats of boiling water. This softens the shell and renders it workable. It is then cleaned and placed into steam molds which shape it into commercial forms. In the East Indies the cruel practice of immersing the live turtles in vats of boiling water or holding them over slow fires until their plates are loosened is frequently recorded. The meat is of no value, having a disagreeable taste and odor.

THE SPINY SOFT-SHELL TERRAPIN, *Amyda spinifer* (Le Sueur), Fig. 6. This fresh-water terrapin occurring along the shores of Lake Champlain and southward except in Delaware; with its related species, the soft-shell terrapin, *A. mutica,* is distinct from all chelonians in that its powerful jaws are covered with fleshy lips instead of the usual horny-sheath. A leathery skin covers the shell, no horny plates being present. The species is fairly common although its flesh has a market value. It has a fierce disposition and feeds in much the same manner as the snapping terrapin. The soft-shelled terrapin can remain under water for several hours as they have true aquatic respiration, taking water into their mouths and expelling it about fourteen times a minute.

Size, Color and Sex: Carapace fourteen inches long. Female wider than male in front on forward edge of carapace with the spiny tubercles larger than those found on male. The plastron is clear white. The tubercles distinguish it from the soft-shell terrapin, *A. mutica.*

THE SOFT-SHELL TERRAPIN, *Amyda mutica* (Le Sueur), Fig. 7. A species closely resembling the spiny soft-shell terrapin in habits and appearance. It occurs in the western part of Pennsylvania along Lake Erie and may possibly be found near Niagara Falls, New York. It is not as common as the foregoing species and less definite information is known about its habitat.

Size, Color and Sex: Carapace six and one-half inches long, the comparative width of the anterior portion determines sex as in *A. spinifer,* the spiny soft-shell terrapin. The carapace is a uniform dull brown and is sometimes blotched. The carapace of the former species has many round dark spots margined with black, while this species is only found spotted in very young specimens. Locality alone should serve to distinguish the species from each other and the presence of tubercles indicates the spiny soft-shell invariably.

THE SNAPPING TERRAPIN, *Chelydra serpentina* (Linne), Fig. 8. With the exception of the sea turtles the snapping terrapin is one of the largest species in the United States.* It is evenly distributed over the entire region of eleven states and is considered a pest for it lives on fish, water-fowl, and small mammals thus becoming fair prey of keepers and wardens of game preserves and wild life reservations. It is ferocious in its way of securing food and voracious in its appetite.

Size and Color: Over two feet long from the tip of its dangerous head to the end of its thick, horny tail. The carapace measures a foot and a half. Specimens of this size weigh thirty pounds or more. Body color black with greyish mottled skin parts.

Habits and Economic Use: Usually found in shallow ponds or along banks of small streams and rivers resting on the bottom and carefully eyeing the surrounding locality. When a water-bird or fish passes near it will shoot its head up with lightning-like rapidity, seizing the creature in its heavy jaws and dragging it to the bottom. Here a few well inflicted bites finish off the coveted prey and then it begins to tear apart the carcass, devouring it in a short time. Medium sized specimens are capable of severely injuring a man's hand and great care must be exercised in handling the terrapin. Grab it by the horny tail and hold it extended at arms length, lest it reach out with its long retractile neck and seize part of the body or clothing of its captor. The meat is sold and furnishes the famous Philadelphia snapper soup. Some old hostelries of that city still raise the turtle flag with the snapper shown against a white background, when terrapin is being served. This custom dates back to the early years of our country.

THE BOX TERRAPIN, *Terrapene carolina* (Linne), Fig. 9. This species, sometimes called the Box Tortoise, exhibits considerable individual variation in shape and color and is common throughout the Eastern states. It prefers the seclusion of open wooded country near small streams but, in its desire to get to better food territory or to find a mate, it also frequents roads and is often run down by careless motorists.

The box terrapin appears to represent a transitional state between terrapins and tortoises. The high-domed shell suggests a tortoise and this thought is reinforced by the club shaped or elephantine limbs that are peculiar to tortoises. On the other hand it is often found in the water and, unlike true tortoises, is a good swimmer, observations having been recorded of its swimming streams. The digits have a small web and tend to spread apart as in terrapins; in tortoises the digits are bound closely together.

Size, Color and Sex: Full grown specimens measure up to seven inches along the middle line of the plastron and for this size are usually about four inches wide. Their colors are made up of a lemon-yellow or orange background splashed with black markings on each shield of their shell. The skin is an orange or yellow hue, this hue corresponding to the color of their shell. Many males have bright red eyes; females sometimes have reddish eyes but these are invariably mottled with black or brown shades. Sex is primarily determined by the rather hollow or concave plastron of the males which differs from the flat, plane-surfaced plastron of the female.

Habits: Often found nibbling the edges of umbrella-like mushrooms and sometimes eating slugs and dead fish that have been washed up on the bank of a stream. This terrapin is prized as a household pet and with some patience will respond to anyone who fancies it for domestic purposes. It is quite tame and has never been known to bite. A bowl of water, some lettuce leaves or raw vegetables daily, bits of fresh raw meat twice a week, and the turtle is quite at home. In captivity it seeks cool dark corners in summer and warm radiators in winter. Its movements are usually restricted to regular trips in search of its food. I have kept several specimens alive in my apartment for periods of two and three years during which time they exhibited every sign of good health.

RED-BELLIED TERRAPIN, *Pseudemys rubriventris* (Le Conte), Fig. 10. Next to the snapping terrapin this is the largest terrapin found from Cape Cod to Cape Henry. In New England this aquatic species is restricted to ponds near

---

* A larger species occurs in the southerly states. This is the alligator snapper, *Macrochelys lacertina*, attaining a weight of 125 lbs.

Plymouth, Massachussetts, living in fairly deep water and exhibiting strong swimming powers.

Size, Color and Sex: Carapace twelve inches long by seven inches wide. Carapace brownish, streaked or blotched with red. The red plastron and flesh parts accounts for its specific name, *rubriventris*. Sex is readily determined by the long thin nails on the fore feet of males and the short stubby nails of the females; other dimorphic factors are present but to a lesser extent.

Habits and Economic Use: The species is shy and very active when escaping or disturbed. Hibernation lasts from October to early April in Massachusetts. Food consists of snails, tadpoles, crayfish and water plants. The eggs are laid in June in clutches about five inches wide which are excavated by the tail. A separate hole is made for each egg and then the whole clutch is covered and smoothed over so as to safeguard the eggs from crows and muskrats. This species, often called Slider ranks second to the diamond-back in food flavor.

WESTERN PAINTED TERRAPIN, *Chrysemys marginata* (Agassiz), Fig. 11. This species is like the Eastern painted terrapin in habits, but is not as widely distributed being found in the western part of Pennsylvania and New York and a straggler into northern New Jersey where it was found at the Wyanokie Zoological Station (Haskell, N. J.) in the summer of 1928.

Size, Color and Sex: Size same as the species that follows, the eastern painted terrapin. Colors same but for plastron which has a large blackish oval patch extending from the humeral to the femoral shields and occasionally encroaching on the gular and anal shields. Sex determined as in the eastern species, *C. picta*.

EASTERN PAINTED TERRAPIN, *Chrysemys picta* (Schneider), Fig. 12. This pond terrapin is a familiar form to every boy and girl who plays near ponds or goes wading in brooks. The creature is always on the alert and slides from its bank or log the moment anything disturbs the peaceful quiet of the locality. This habit of sliding off into the water has undoubtedly given rise to the popular name Slider applied to all pond terrapins. Its occurrence is very common.

Size, Color and Sex: Carapace five inches long by three and three-fourths inches wide. Black or deep olive above, each plate margined with yellow and throat striped with yellow. The plastron is an immaculate lemon-yellow. The marginal plates are "painted" with a brilliant red; hence the name painted terrapin. The vertebral plates are nearly in the same line as the costals; in the western painted terrapin these plates alternate. Sex is determined as in the red-bellied terrapin.

MAP TERRAPIN, *Graptemys geographica* (Le Sueur), Fig. 13. The map terrapin is found along the shores of Lake Champlain, in New York and Pennsylvania rivers having their outlet in Lake Erie and was probably introduced in Bayside, New Jersey.

Size, Color and Sex: In large specimens the carapace measures nine and one-half inches. The color arrangement has given rise to its popular name, Map Terrapin. Carapace olive or brown, covered with thin reticulate green or yellow lines. The plastron is a pinkish-yellow in newly captured specimens. Sex again is determined as in the red-bellied terrapins.

Habits and Economic Use: Food is swallowed under water, consisting of mollusks and crayfish. The shape of the notched beaks adapts the terrapin for this type of hard shelled food. Like the red-bellied terrapin, it is used as a food substitute for the diamond-back, being less expensive as it is more abundant than other edible species.

DIAMOND-BACK TERRAPIN, *Malaclemys centrata concentrica* (Latreille), Fig. 14. The diamond-back species of this article ranges from Buzzards Bay in Massachussetts to Chesapeake Bay in Maryland. These terrapins inhabit the salt and brackish coastal marshes and were once very abundant. However, as its flesh is regarded as one of the greatest treats known to gourmands, the demand for them has resulted in overfishing and a marked decrease in their numbers has resulted. In 1923 the price for terrapins having a six inch plastron (average size) was $35.00 per dozen, while larger specimens commanded higher prices. This condition led the state of North Carolina to prohibit the taking of diamond-backs for a five-year period and the state in cooperation with the Bureau of Fisheries began experiments in an effort to save the species from extinction. At Beaufort, N. C., such work is carried on and the accompanying photographs taken by Mr. Pinney Schiffer, tell the story of terrapin culture. The species is still very rare and every effort must be made to foster measures to rehabilitate a terrapin so useful in man's larder. Circular No. 60 of the Bureau of Fisheries Dept. of Commerce, should interest all persons desiring to learn more about the diamond-back.

Size, Color and Sex: Plastron six to seven inches long. Shell rough with each plate showing deep concentric growth rings. Carapace dark-olive or greyish; plastron yellow. For sex factors see photographs facing Fig. 14.

Muhlenberg's Terrapin, *Clemmys muhlenbergi* (Schoepff), Fig. 15. This attractive terrapin is found near peat and sphagnum marshes. The gradual reclamation of these areas will doubtless result in the disappearance of the species for it does not seem to thrive when this ecological environment is changed. In New England it is found in one corner of Rhode Island and when it occurs in other states it only does so in widely separated localities. These gaps in distribution are accounted for by the isolated and widely scattered location of sphagnaceous swamps over the mass of the terrain. Its related forms, all members of the genus *Clemmys,* are usually found in the same places, although these species (the spotted and sculptured terrapins) appear in many states and under conditions adverse to Muhlenberg's terrapin. In habits the group is a semi-aquatic one, their food embracing a variety of the smaller floral and faunal representatives. They are all harmless and seem to do well in captivity.

Size, Color and Sex: Specimens collected at the Wyanokie Zoological Station measured three and one-half inches along the carapace. The body is a uniform dark brown having a bright red or orange spot on the hinder portion of each side of the head. This marking identifies the terrapin at a moment's glance. Concavity of the plastron, longer nails, and heavier tails set the males apart from members of the opposite sex. Females exhibit a plane plastron, short nails and short tails thickened at their bases. These factors apply to the other wood terrapins, the spotted and the sculptured terrapins.

Sculptured Terrapin, *Clemmys insculpta* (Le Conte), Fig. 16. The deeply chiseled markings on the shell of the species serve as a guide in rendering the popular name in harmony with the specific one (*insculpta*). The terrapin is eaten in many country places, the strawberry colored legs supplying the meat for a delicate preparation called "country turtle." As in most terrapins, with the exception of the Box, mating takes place in or close to water; occurring in the spring with hibernation lasting from late fall through the long winter and into late April when the fertilized eggs are laid. The eggs hatch out during the same summer. It is an established fact that a female will return to the same nesting grounds year after year and will only seek another when local conditions make egg depositation absolutely impossible.

Size, Color and Sex: A large species having over a seven inch length of carapace. The shell is a light brown, while the plastron beneath is blotched with black on every shield. The limbs and flesh parts are a bright orange while the head retains the general body color or is black on top and brown beneath. Sex as in Muhlenberg's terrapin.

Spotted Terrapin, *C. guttata* (Schneider), Fig. 17. This common species exhibits two distinct phases in the form of its shell as it is found in both fresh and brackish water; the former habitat producing a smooth black shell while the latter results in a sculptured and rusty looking shell. The terrapin resembles the two former species in respect to locality and habits and is intermediate in size and form to the large sculptured terrapin and the small Muhlenberg terrapin.

Size, Color and Sex: Carapace four and one-fourth inches in length. Females smaller in size than the males with tails only half as long. The females, like the males, are covered with little yellow dots on each shield but have about 15% more of these dots and perhaps this renders them conspicuous in the pairing season. Other sex factors apply as in the examples given for the two foregoing wood terrapin.

Mud Box Terrapin, *Kinosternon subrubrum* (Lacepede), Fig. 18. As seen from the generic name (*Kinosternon*) the species is related to the musk terrapin. (See account on musk terrapin). It has the same vicious habits and emits the same musky odor when handled and at mating. Its plastron, like that of the box terrapin, is hinged and when closed can cover all the fleshy parts.

Size and Color: Carapace three and one-half inches long by two and one-fourth inches wide;

plastron three inches long by one and three-fourth inches wide; color dark brown with the same modifications as the musk terrapin. The plastron shows lines of annual growth as in many other terrapin. From the center of the original shield, one growth ring is added every year and by counting the rings on several shields and taking an average a figure will appear that may be used to indicate the age of a specimen. In old individuals these rings are often eradicated by wear.

Musk Terrapin, *Kinosternon odoratum* (Latreille), Fig. 19. The species inhabits small, sluggish streams and ponds. Like its related form, the mud-box terrapin, it emits a disagreeable musky odor from scent glands having their openings under the fore limbs. This heavy and somewhat fetid scent serves to attract prospective mates and to repel other animals.

Size and Color: The carapace averages three and one-half inches long by two and one-fourth inches wide; dark brown, striped or blotched with a deeper color but it is oftentimes covered with a fine green pond slime that renders these colors inconspicuous.

Habits: In disposition its ferocity and ill temper resemble that of the snapping terrapin. This unpleasant creature feeds entirely on animal food, stomach contents revealing fish, crayfish, slugs, worms and insects to be its diet. Care should be exercised in handling specimens lest nasty bites be inflicted. The musk has never been utilized by perfumers, possibly being of an inferior quality.

Author's Note: Mr. E. R. Sanborn's photographs and suggestions have greatly contributed to this issue, as well as the critical help of Mr. J. T. Nichols and Dr. R. L. Ditmars.

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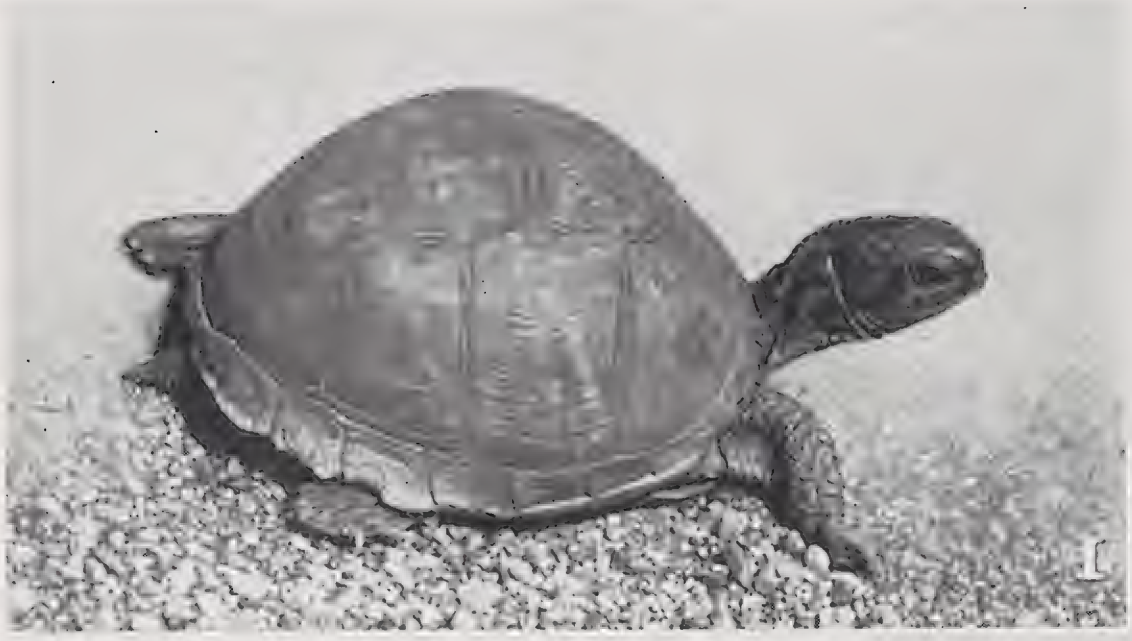
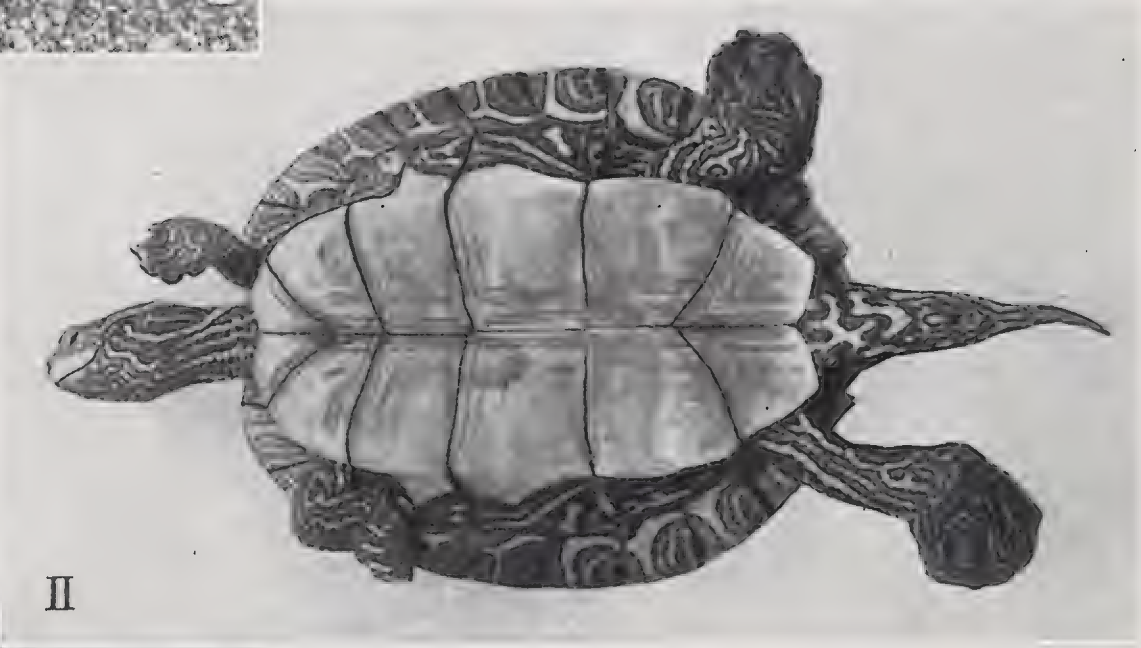
REGIONAL ADAPTIVE RADIATION

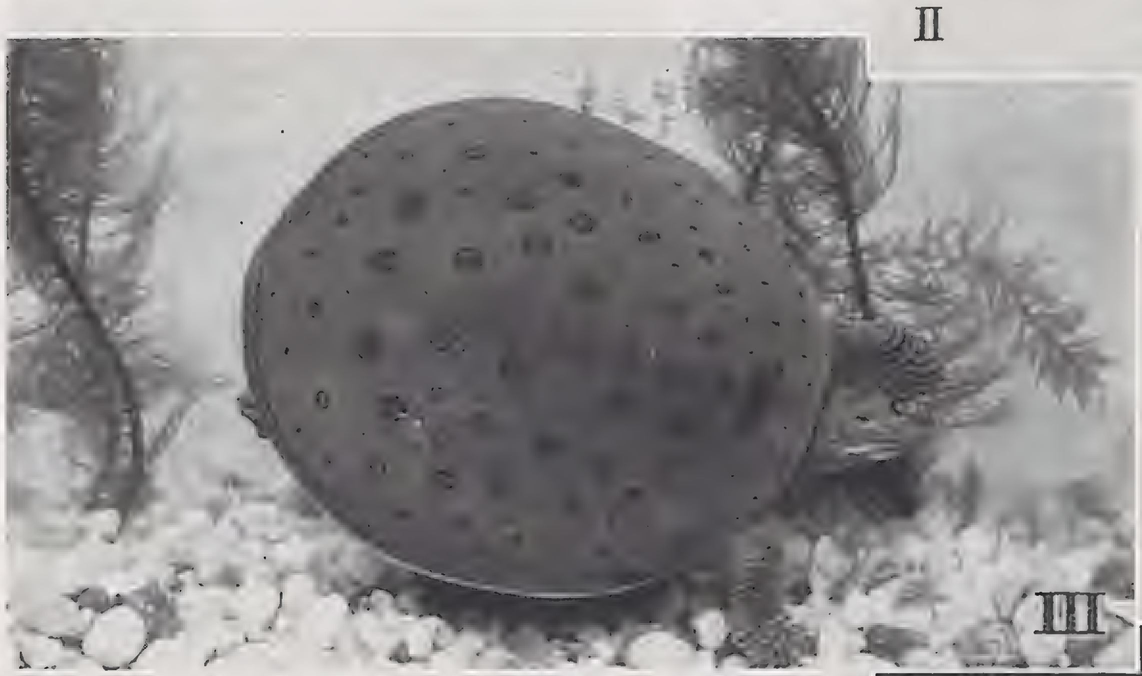
Turtles so differ in structure and habits as to prevent competition. Radiating from their original home—the land,—to ponds, swamps, rivers and the sea; these four typical turtles have filled all available habitats of this region. Radial adaptation to regional environment is the factor of natural selection which has made for their survival.



I—The highland-living Box Terrapin exhibits the ambulatory or terrestrial type of limb adaptation; with typical tortoise characteristics: a high and dome like shell, club shaped limbs with stubby nails and a very short tail. The creature's habitat is usually high and dry land, which is said to be the original habitat of turtles.

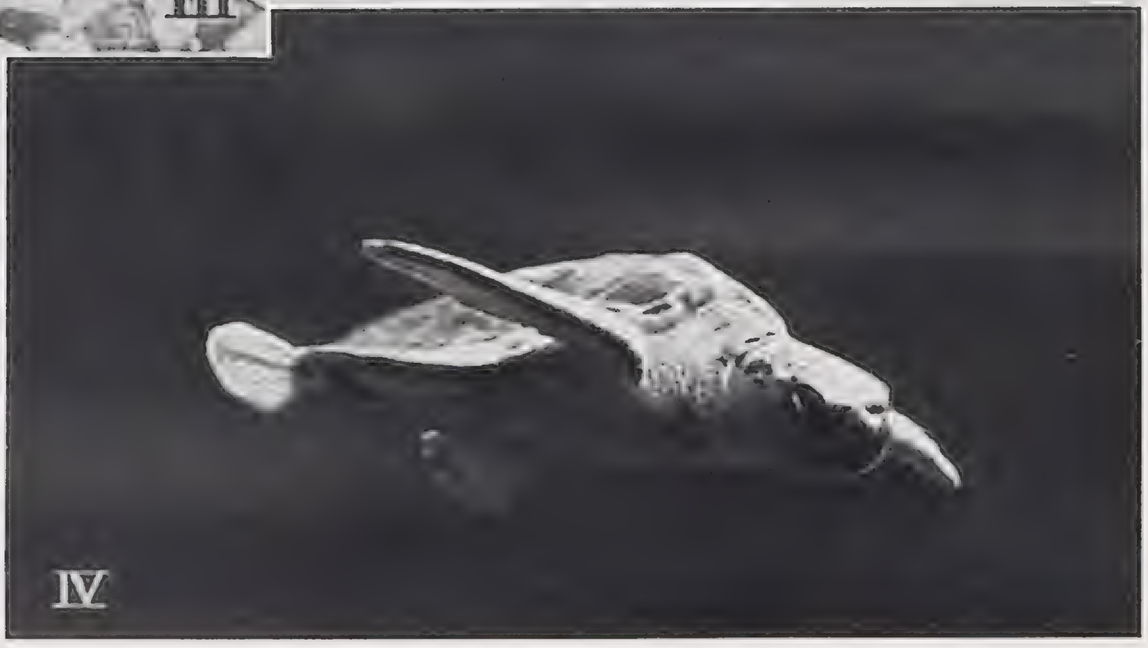
II—The pond-living Map Terrapin indicates an important transitional stage from terrestrial to amphibious life with a corresponding limb adaptation showing typical terrapin characteristics: a depressed arched shell, webbing between the slender nails of the flat feet and a long tail which is useful as a rudder in swimming. The habitat is restricted to ponds and lakes.





III—The river and swamp-living Spiny Soft-shell Terrapin shows the extreme of transition to aquatic life in that its limb adaptations are of the natatorial type while the completely flattened body, covered with a leathery skin and containing few bony structures, indicates high evolutionary development. The feet are completely webbed and palmate in shape.

IV—The marine-living Kemp's Turtle represents the ultimate in adaptation to environment. The fore limbs are fused into powerful swimming organs: paddle-like flippers; the body is beautifully stream-lined and so presents a minimum of resistance to the surrounding media (the water); while the hinder limbs, also paddle shaped, serve admirably as steering rudders during swimming.



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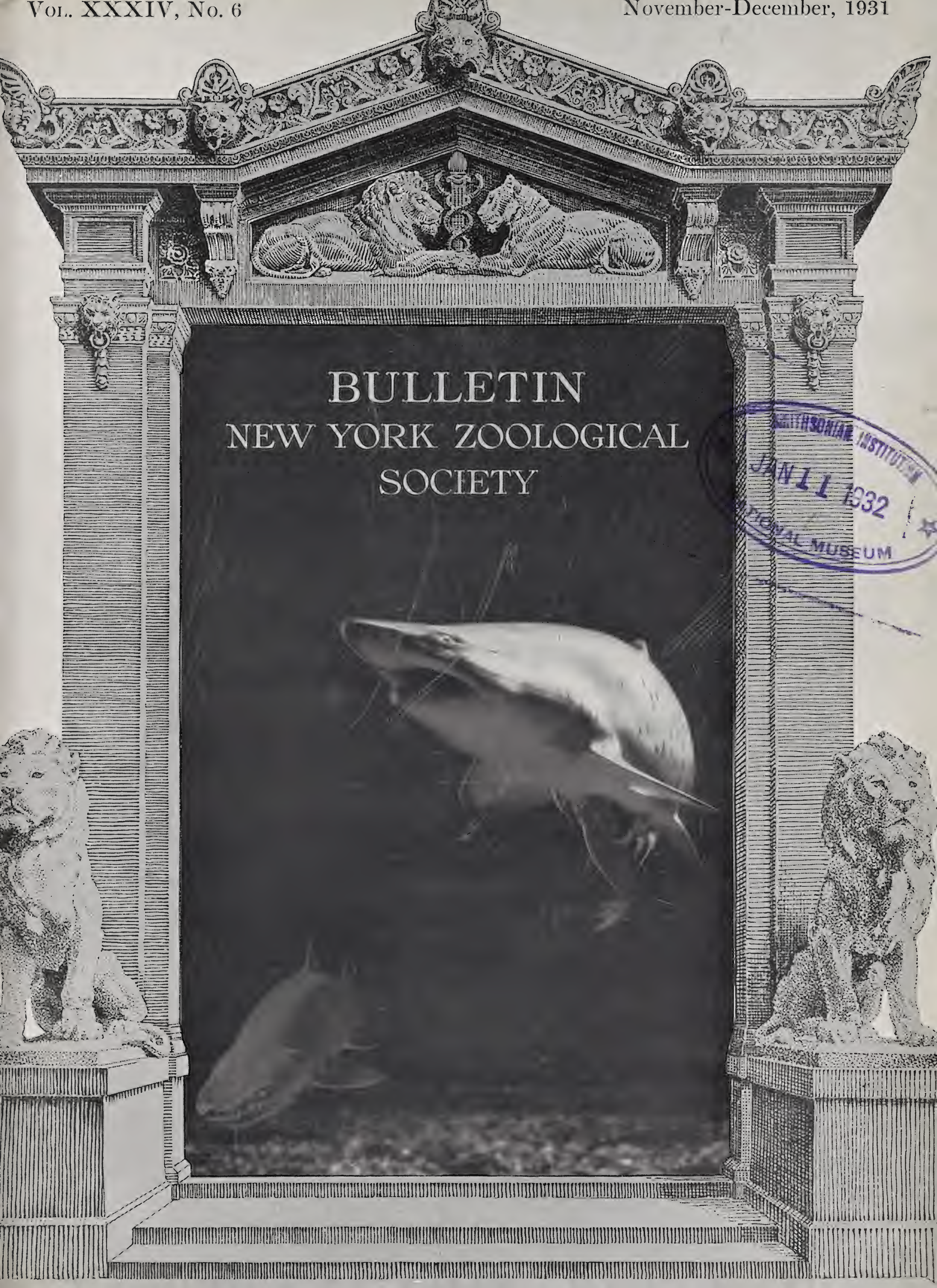
NEW YORK ZOOLOGICAL SOCIETY



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SHARK AND SHARK-SUCKER......................*Photograph by Elwin R. Sanborn* Cover

BULLETIN

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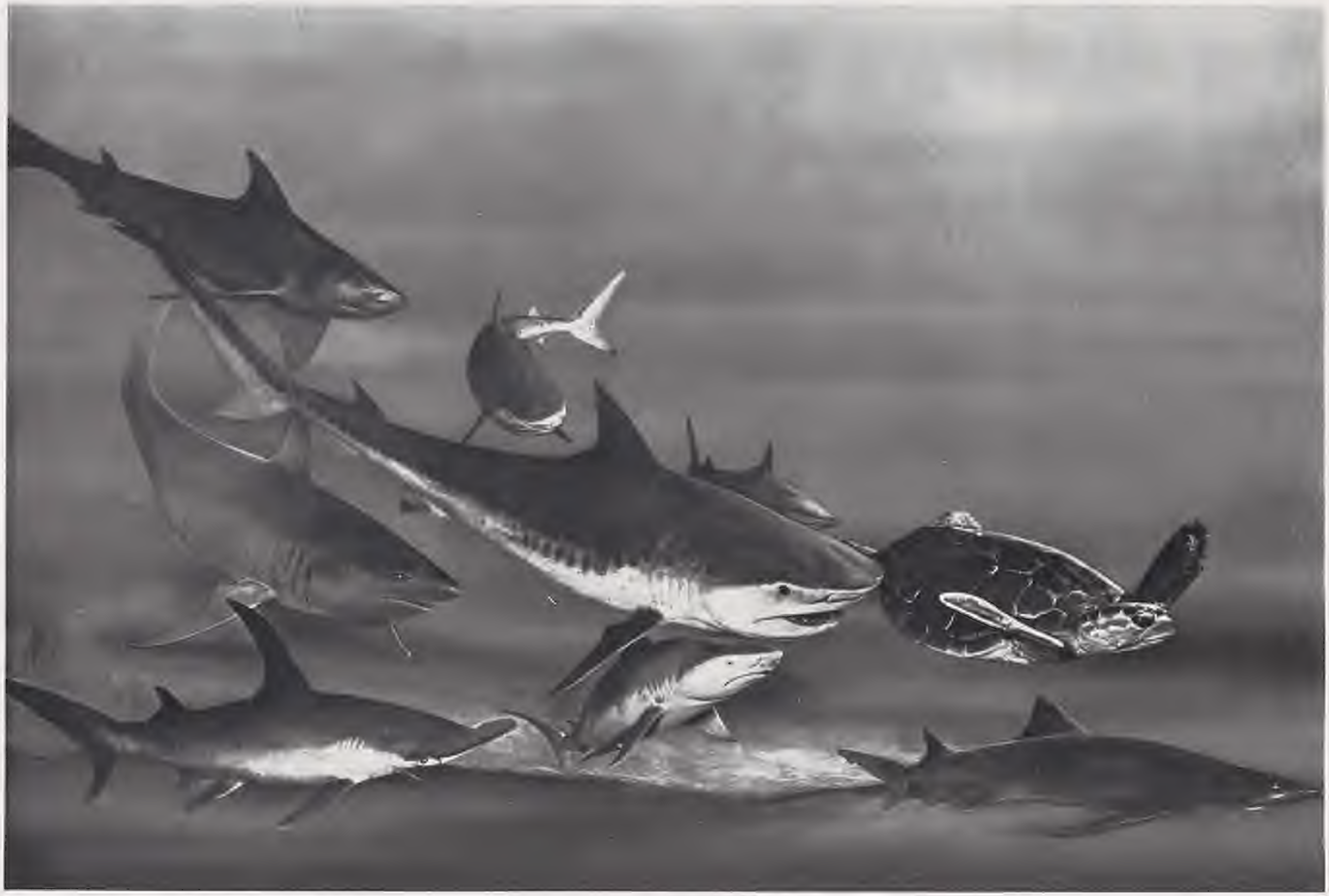

A school of sharks, led by a twelve-foot tiger shark, attacking a sea turtle. On the left is a large hammerhead shark, and in the background a huge man-eater. Sketch from the group in the American Museum by F. L. Jaques.

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Concerning the Shark

Charles Haskins Townsend

Illustrations made from photographs taken in the New York Aquarium and various other sources as noted under the cuts.

If the New York Aquarium did not exhibit living sharks, there would be fewer questions for us to answer as to how dangerous they are. The sharks are still on view. If we may judge public interest in the future, by what it has been in the past, the present contribution on the subject should serve to increase the sale of the Bulletin to visitors.

There was a time when I was more or less skeptical about the shark as a man-eater but after several cruises in the tropics with the *Albatross* my views underwent a change.

Our first observations on the shark were made one dark night off the Bahamas. The *Albatross* was sounding in the Gulf Stream and as was the custom when the ship was sounding on calm nights, insulated and hooded electric lights were suspended a foot or more in the water on each side of the vessel and a couple of yards clear of the side. With gauze dip-nets the naturalists on board could pick up many small forms of surface life attracted by the light and otherwise not readily obtainable. On this occasion a school of young flying fish, dazzled by the unusual illumination, remained near enough to be reached with the long-handled nets and many were secured.

Someone having observed a shark, the sailors put over a heavy shark hook with chain and stout line attached, and in a few minutes the big fish was dragged on board and killed. After being examined by the naturalists and more or less hacked by the sailors, it was thrown overboard. In a short time the ship was surrounded by sharks, the submerged and shaded lights rendering them visible. The shark tackle was kept busy and in half an hour the sailors had hauled on board and killed nearly a dozen, when the officer of the watch objected on account of the sanguinary mess on the deck. The sharks attracted by the bloody carcases gradually being thrown overboard provided an exhibition of how hungry sharks behave in the presence of an unexpected supply of food. Someone said to Lieutenant Benson (now Rear Admiral): "The water's fine; let's jump in." "Jump in yourself," he snapped, "I don't want a bath at present."

Sharks were usually around when the ship stopped for sounding or dredging in calm weather day or night and the sailors often caught them. They must be rather evenly distributed over the watery wastes for they soon appear in any warm sea when a vessel stops. At first there is a lone shark swinging carelessly about the ship, evincing no special interest in it. Other stragglers appear each taking his own leisurely course. The size of the company depends chiefly upon the duration of the ship's stay but it may be affected considerably by

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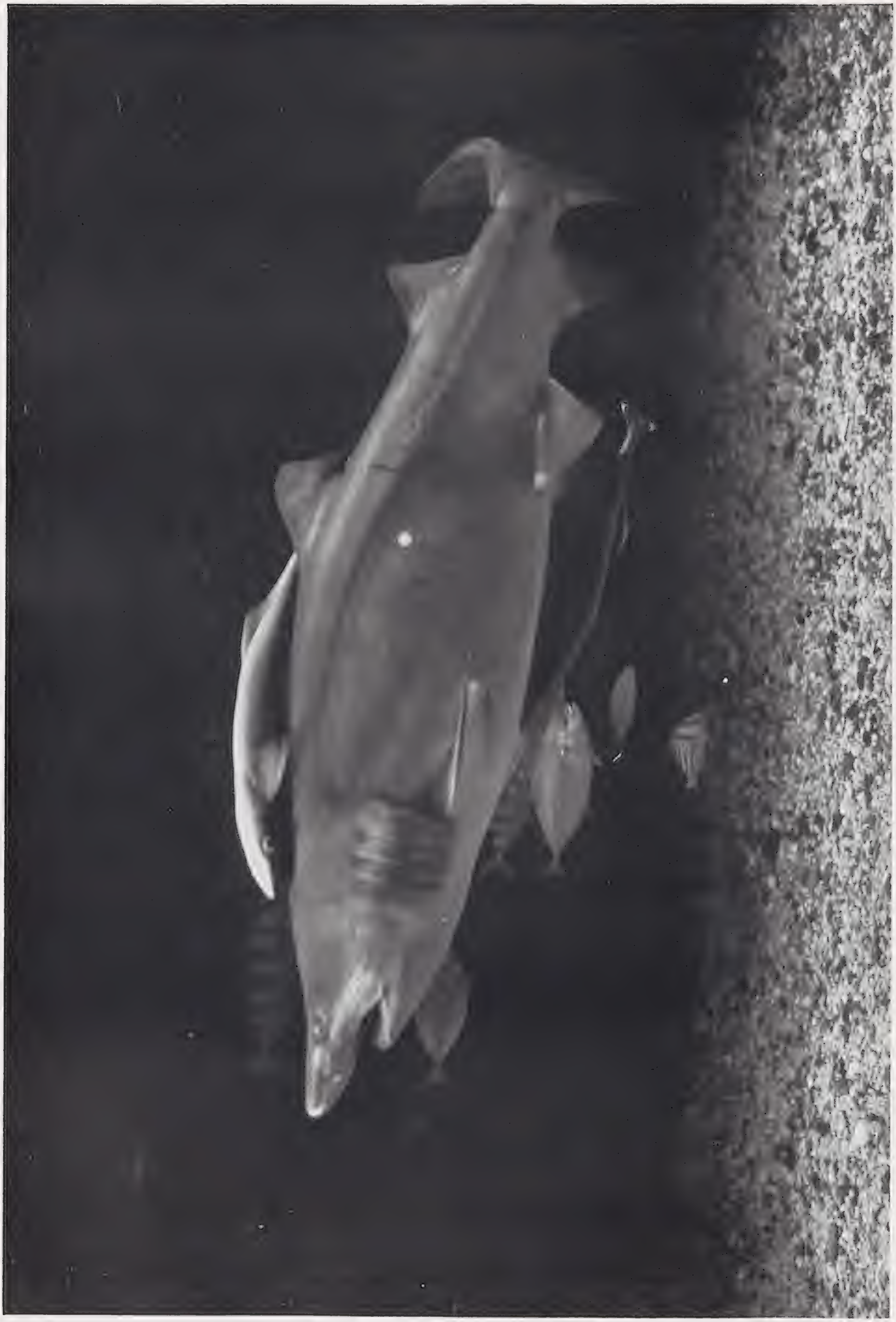
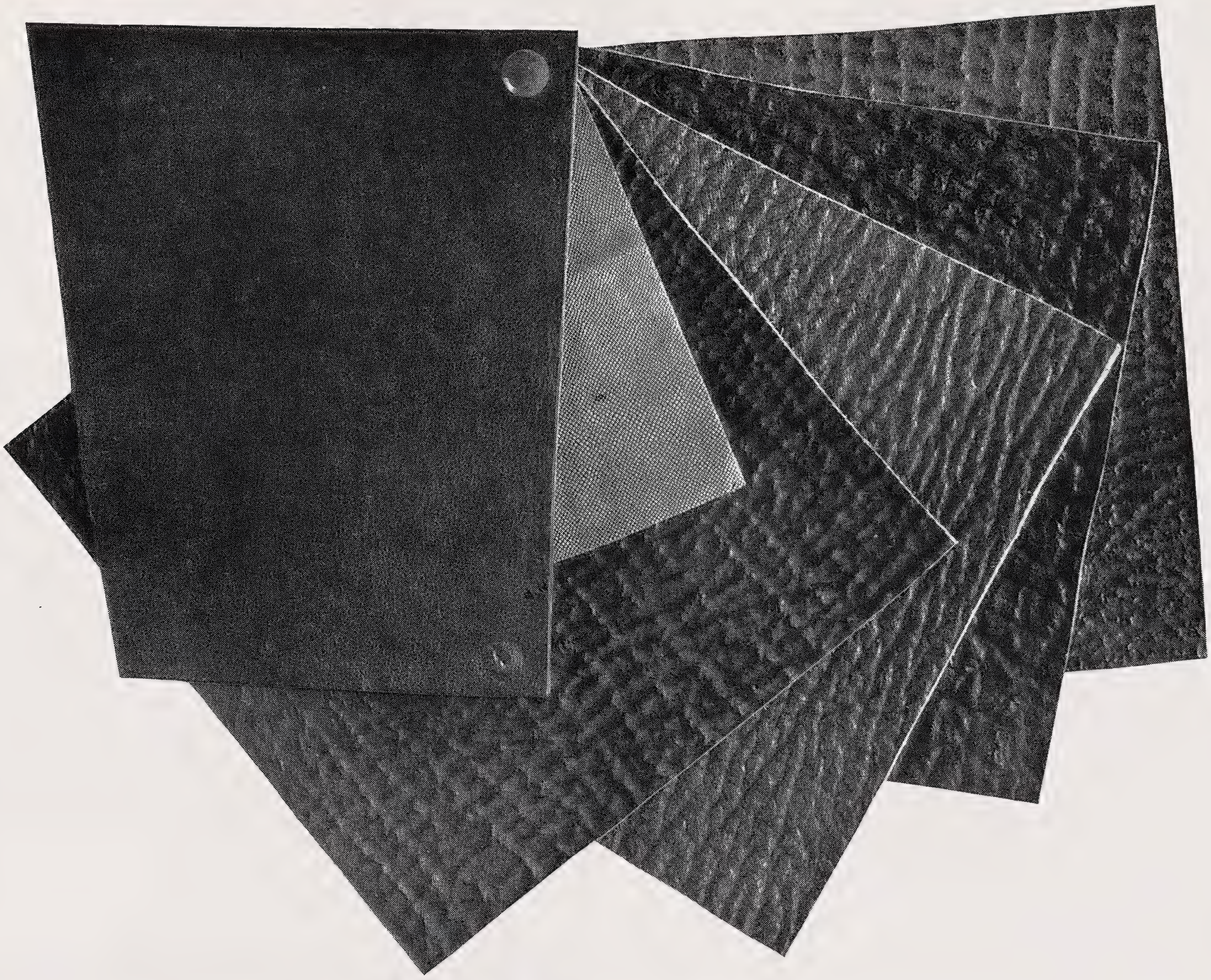


Shark, with his satellites—shark-sucker and pilot-fish. The other fishes shown in the photograph do not seek the shark's company. Photograph by Elwin R. Sanborn.



Samples of shark leather. Black, brown and tan—smooth and shrunken.

what the cook's mate has been throwing into the galley chute. The killing of one of the sharks is usually followed by a rapid increase in numbers, provided the evidences of its violent death have been washed off the deck into the sea.

It is likely that sharks can detect the beat of a steamer's screw at great distances but they gather as readily about a becalmed sailing vessel. The explanation probably is that the wandering selachians discover the more or less oily wake of the ship and follow it. We cut open the sharks killed from time to time to ascertain the nature of their food but discovered little more than such kitchen wastes as had been thrown overboard. There is little in the way of galley refuse that sharks will not pick up. We found by dissection that they swallowed things indiscriminately; there were ham bones, mouldy bread, decayed oranges, greasy rags, oily cotton waste from the engine room, empty sardine tins, and parts of other sharks killed by the sailors. When sharks have been excited by a few mouthfuls of food, they will seize almost anything. A fourteen-foot shark in captivity at Honolulu, after being fed a large piece of meat, seized a box a foot square and crushed it. The stomach of another large shark taken at Honolulu contained a horse's leg with hoof and shoe, a gunny-sack, a tin can six inches square, one squid, a peck of turtle shell and various small articles. It is evident that some of the stuff so cheerfully swallowed is indigestible.

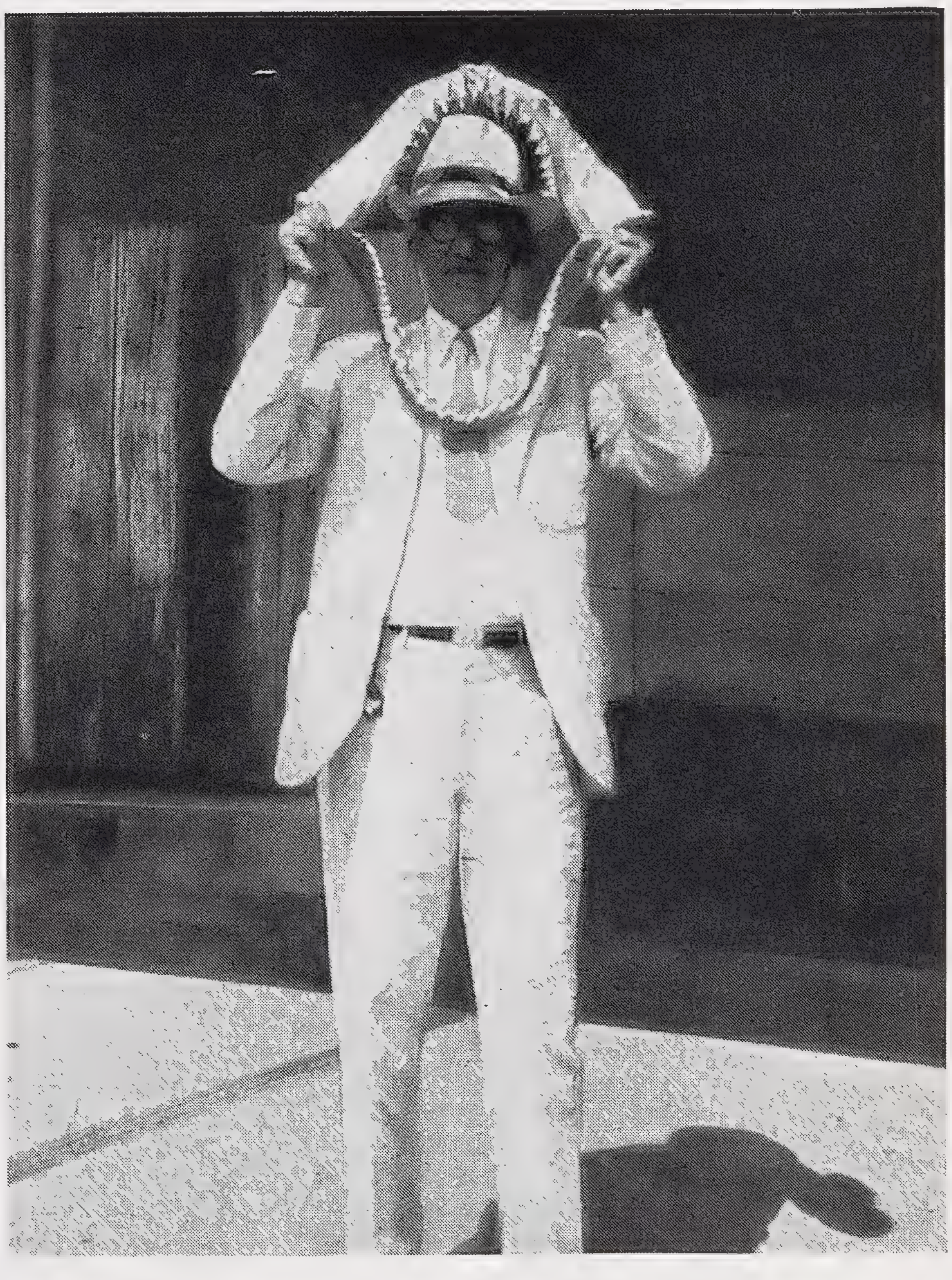
When our deep-sea explorations had carried us among the islands of Eastern Polynesia we caught many kinds of sharks large and small. The sailors were always ready to amuse themselves by dragging them on board for our examination. As we became acquainted with the island traders and natives we learned that they regarded sharks as dangerous under certain conditions and were accordingly circumspect in dealing with them. After a couple of winters'

Shark fishing station at Djibouti, French Somali.
Photograph from Capt. W. E. Young.

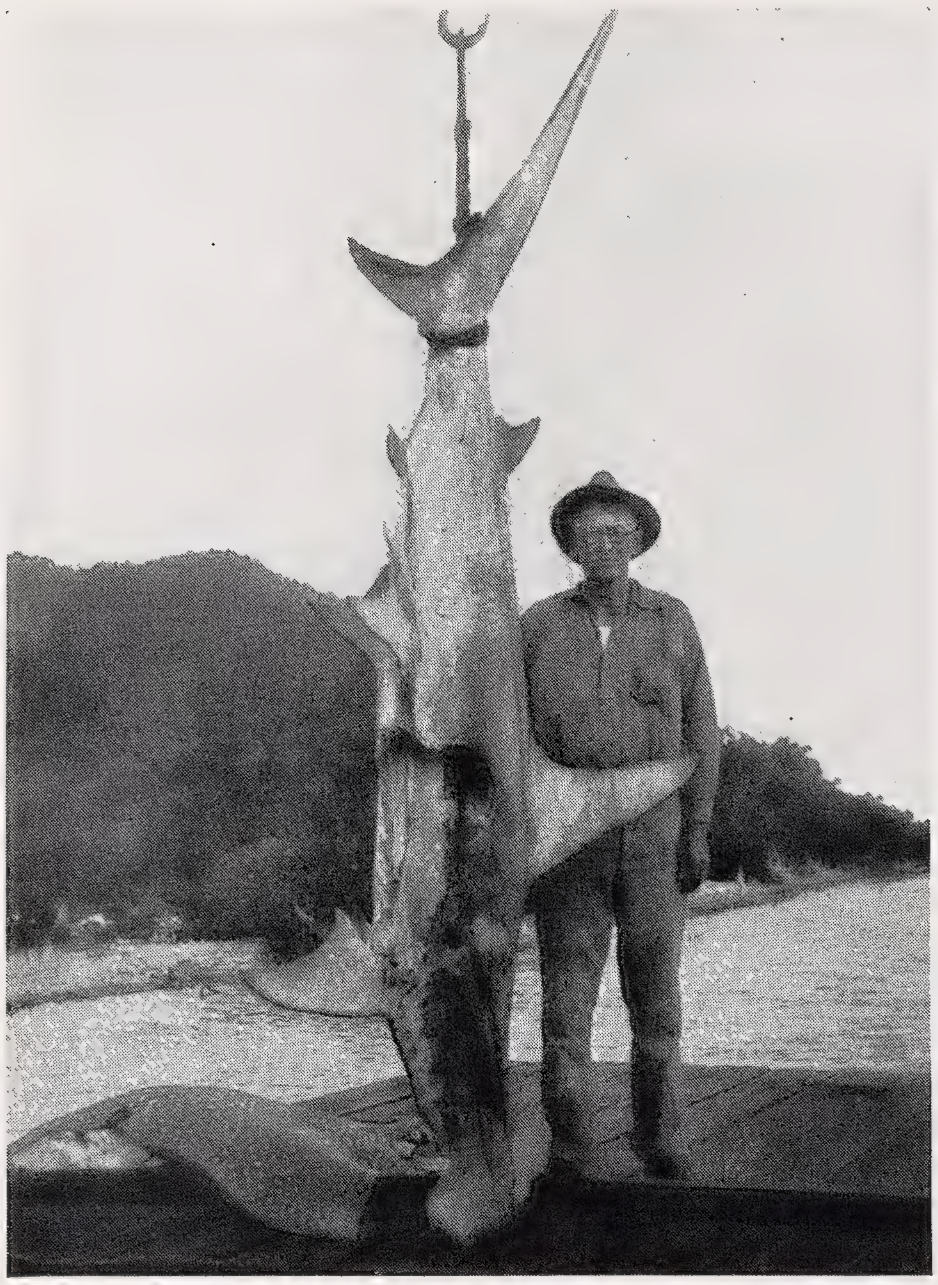
work in tropical waters we came to realize the great abundance and ferocity of sharks and that danger from them was not confined to those of large size. Each group of islands had its tale of injuries or fatalities to human beings from small or large sharks. A shark not so large as a man can easily mutilate and pull down the helpless swimmer without having the size to carry him away bodily.

The Polynesian has the same regard for the shark's prowess that the African has for the lion and like the latter, does not fear to hunt and kill him when the conditions are favorable. The shark however, takes no such toll of human life as he cannot stalk his prey on land. The Polynesian is amphibious and in some parts of the South Seas will plunge down after a lone shark and kill it with a knife, but this exploit is not attempted with all kinds of sharks, nor indeed, by many natives.

The attitude of the native toward the shark is different in the daytime from what it is at night; the shark has the advantage in the dark and is more aggressive. In some parts of the South Pacific where sharks are numerous, they are persistent in following boats and canoes at night, nipping at the oars and paddles and not infrequently at the light outriggers of the native canoes. Large sharks are especially dangerous at night and frequently tear heavy oars away from the hands of the rowers. There are many authentic cases in which they have seized the floating outriggers—used on all South Sea canoes and capsized them with fatal results to the occupants. A tragedy of the Ellice Islands was related to us at widely separated points in Polynesia. About forty natives, crossing in canoes at night between islands several miles apart, were caught in a squall. One of the canoes was swamped and the occupants were seized by sharks which had been following the fleet of boats and nipping the paddles. In a few minutes great numbers of maddened sharks were seizing paddles and outriggers, until all the canoes but one had been swamped and their occupants devoured. Two natives only escaped to describe the disaster. A similar account we got in the Fijis where one of the large double sailing canoes was capsized well off shore and over twenty natives clinging to the wreck were pulled



Jaws of white shark. St. Lucia, West Indies.
Photograph from Capt. W. E. Young.



Hammerhead Shark (*Sphyrna zygaena*), torn by another shark while fast in net. Shark-leather Station. Photograph from Capt. W. E. Young.

under by sharks only a few escaping.

When in the Low Archipelago we found that the natives often swim and dive freely in the lagoons of certain atolls, when they would not think of doing so in the deep entrances to the atolls, where a big lone shark keeps watch. He can be seen about dusk and it's best to visit him in the whaleboat. Natives will sometimes swim about anchorages or even bathe near the deep entrances to lagoons in the daytime, when they could not be persuaded to do so at night. Sharks are often so abundant about certain islands, that a regular fishery is maintained for shark fins—always marketable in China.

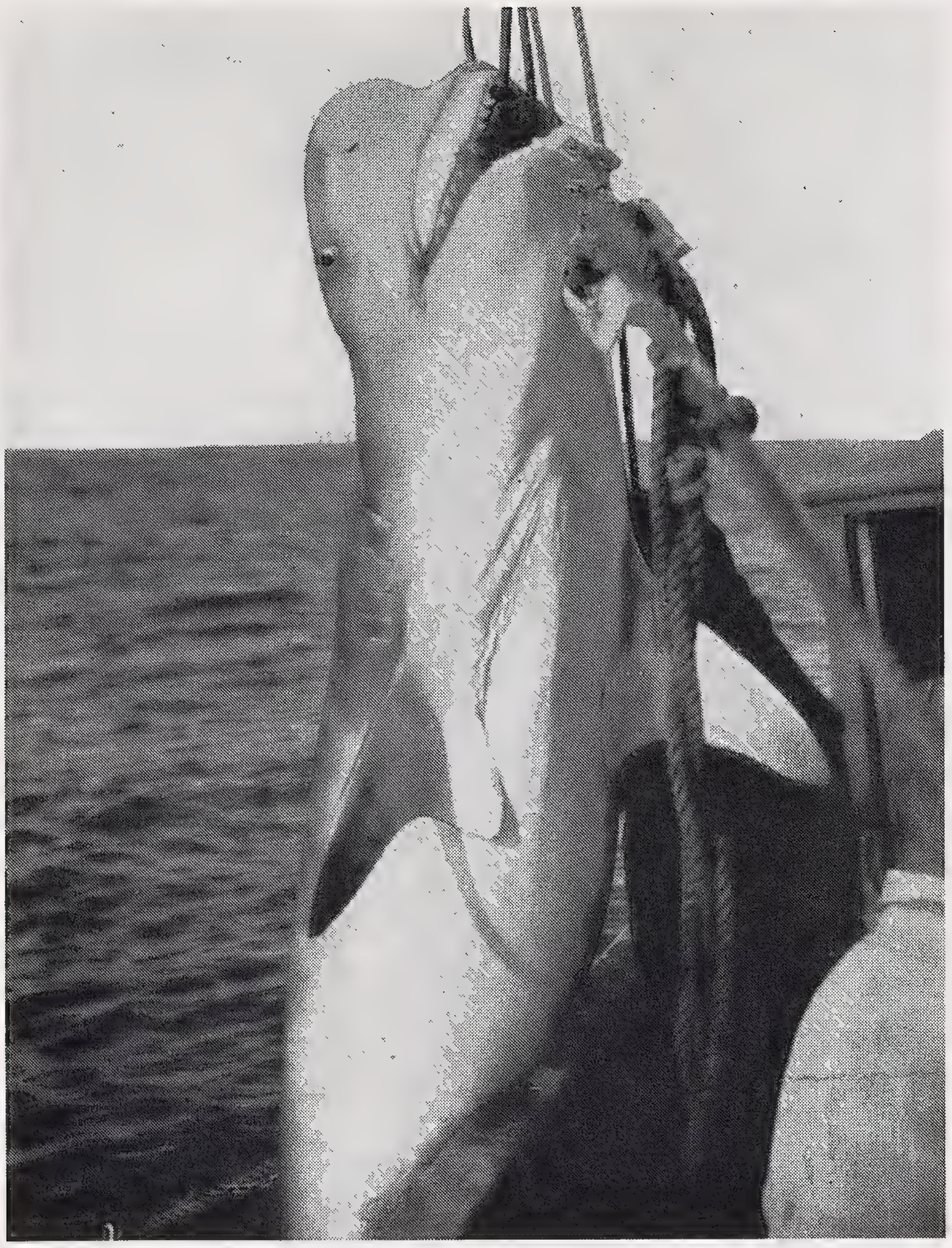
There are reefs here and there among the islands to which the natives resort for some of the larger food fishes and such places are usually infested with sharks which cause great annoyance by following the canoes and seizing fishes that have been hooked. When a too persistent shark menaces the frail canoe it must be beaten off with paddles or fish spears. The native fishing on the more distant banks off shore will gladly avail himself of the use of a good-sized dinghy or whale boat which has no outrigger to be seized by an ugly shark. It is not by any means the largest sharks that are most dangerous. Many small but active species move in schools and at times actually swarm about a canoe, not merely interfering with fish catching but endangering the light craft.

Sharks have always been regarded as distinctly dangerous in Australian waters where there are several large species. They were particularly so at Sydney, where for a time butcher shop wastes were allowed to be thrown into the harbor. Swimmers about the docks were carried off by sharks on several occasions in the daytime. In the Solomon Islands the singular ferocity and boldness of the sharks are said to be due to the native custom of throwing dead bodies into the sea. Where the carrion is, there will the vultures be gathered together. At such times sharks come to eat and their temper is not misjudged by those who understand them.

At Pepekeo, Hawaii, in 1907, a Japanese fisherman holding a net fell from his boat and persons on the cliff near by who could do nothing to help him saw him pulled under by a shark.

On October 8, 1907, a Japanese fisherman at Kalepolepo, Island of Maui, while diving to take

Shark boat, *Venus*, with shark gill-nets, Shark-leather Station, Virgin Islands. Photograph from Capt. W. E. Young.



Tiger Shark (*Isurus tigrinus*), Shark-leather Station, Porto Rico. Photograph from Capt. W. E. Young.

fish from a net was seized by a shark which stripped the flesh from his arm. He was taken to the hospital at Wilku where the arm was amputated at the shoulder.

On January 8, 1908, at Mana, Island of Kauai, a Japanese fisherman swam out to gather fish floating on the surface which had been killed by dynamite. When warned of the presence of a shark, he swam frantically for the rocks but was seized and pulled under. As he disappeared in blood stained water, it was seen that he had his arms around the shark's body.

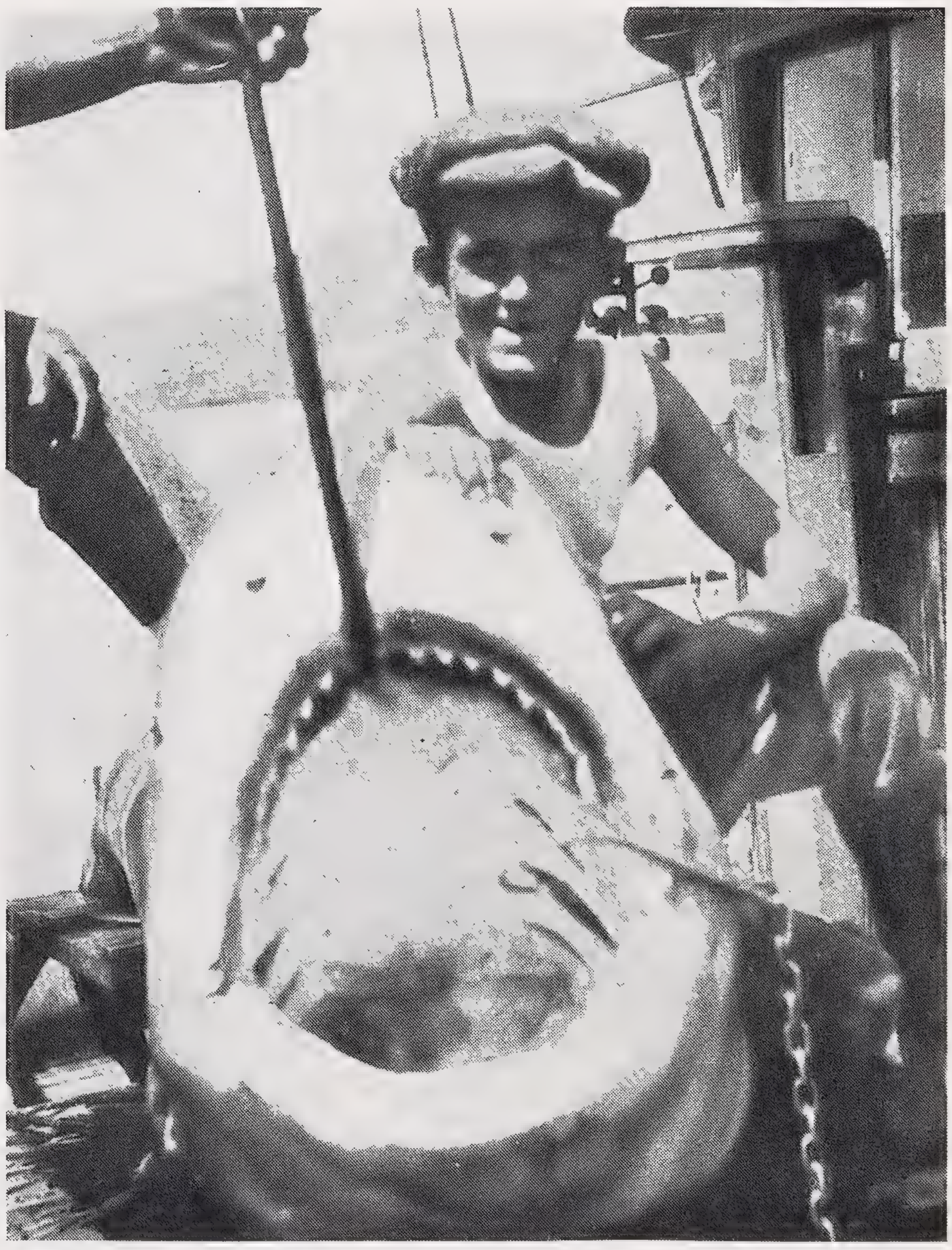
At Hilo, Hawaii, in 1910 two fishermen in a small boat were thrown into the water by a heavy sea. One reached a place of safety but the other was forced to cling to the rocks at the water line. Before he could be rescued a large shark carried him off.

In March, 1914, a Japanese gathering shellfish near Honomu, Hawaii, was observed to be engaged in a struggle of some kind. Before help could arrive two sharks had carried his body beyond reach.

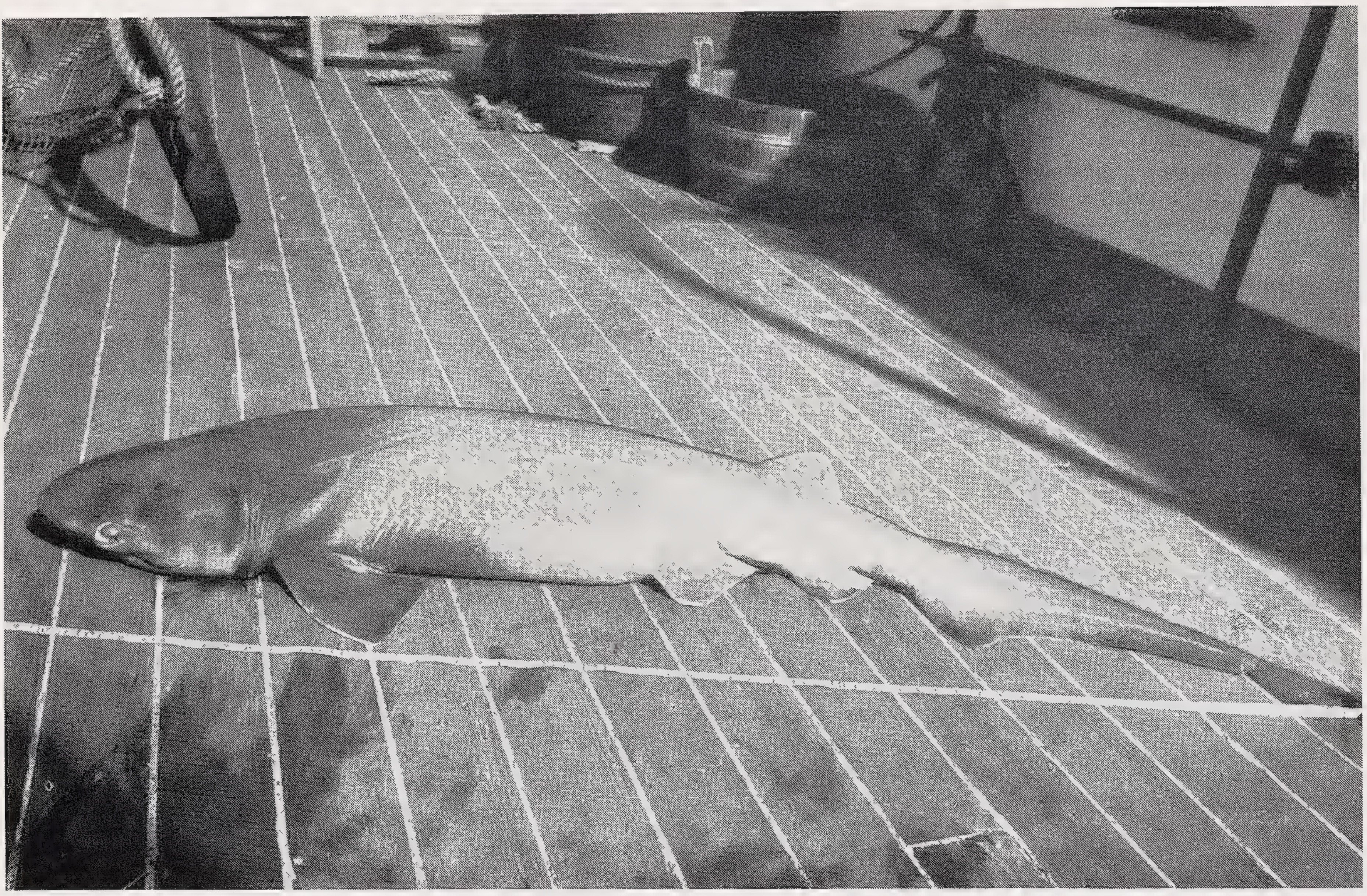
It is unnecessary to continue the recital of the gruesome records in my note- and scrap-book begun many years ago when we surveyed the Hawaiian cable route. The *Albatross* sounded every five miles along the 2000-mile track between San Francisco and Honolulu. Every stop lasted an hour and toward the southwestern end of the route there was plenty of opportunity to get acquainted with sharks and put numbers of them out of business. Sailors like to torture sharks. We had to forbid such practices as propping their jaws wide open with a stick, or cutting off their tails and then heaving them over alive but helpless.

The customary question of the skeptical, "Did you ever see a man killed by a shark?" may properly be met with a similar one: "Did you ever see a man murdered?" In conversation there is generally some one to defend the shark. I usually say, "don't care to bother with amateurs."

Natives in the Hawaiian Islands are cautious about venturing into deep water near steep cliffs and then seldom without a long bladed knife. The native surf-board riders disport themselves in waters where sharks are not often



Mouth of tiger shark, with seven rows of teeth, numbering 250 to 300, having cutting edges that shave like razor blades. Photograph from Capt. W. E. Young.



Six-gilled Shark (*Hexanchus corinus*), coast of Washington. A Pacific representative of a very large *Hexanchus* found in the North Atlantic. Photographed on the U. S. S. *Albatross.*

seen, the shallowness of the water and the disturbance made by the surf-board riders serving to keep the sharks at a distance, but accidents occur.

We need not consider here the comparatively few instances of loss of life from these big fishes in northern waters. It is in the warmer seas where sharks of all kinds are more abundant that we find them a menace. And yet the tragedies are rare. Sharks do not likely succeed in killing as many persons in a year in all Polynesia perhaps, as are killed by automobiles in any large American city in a single week.

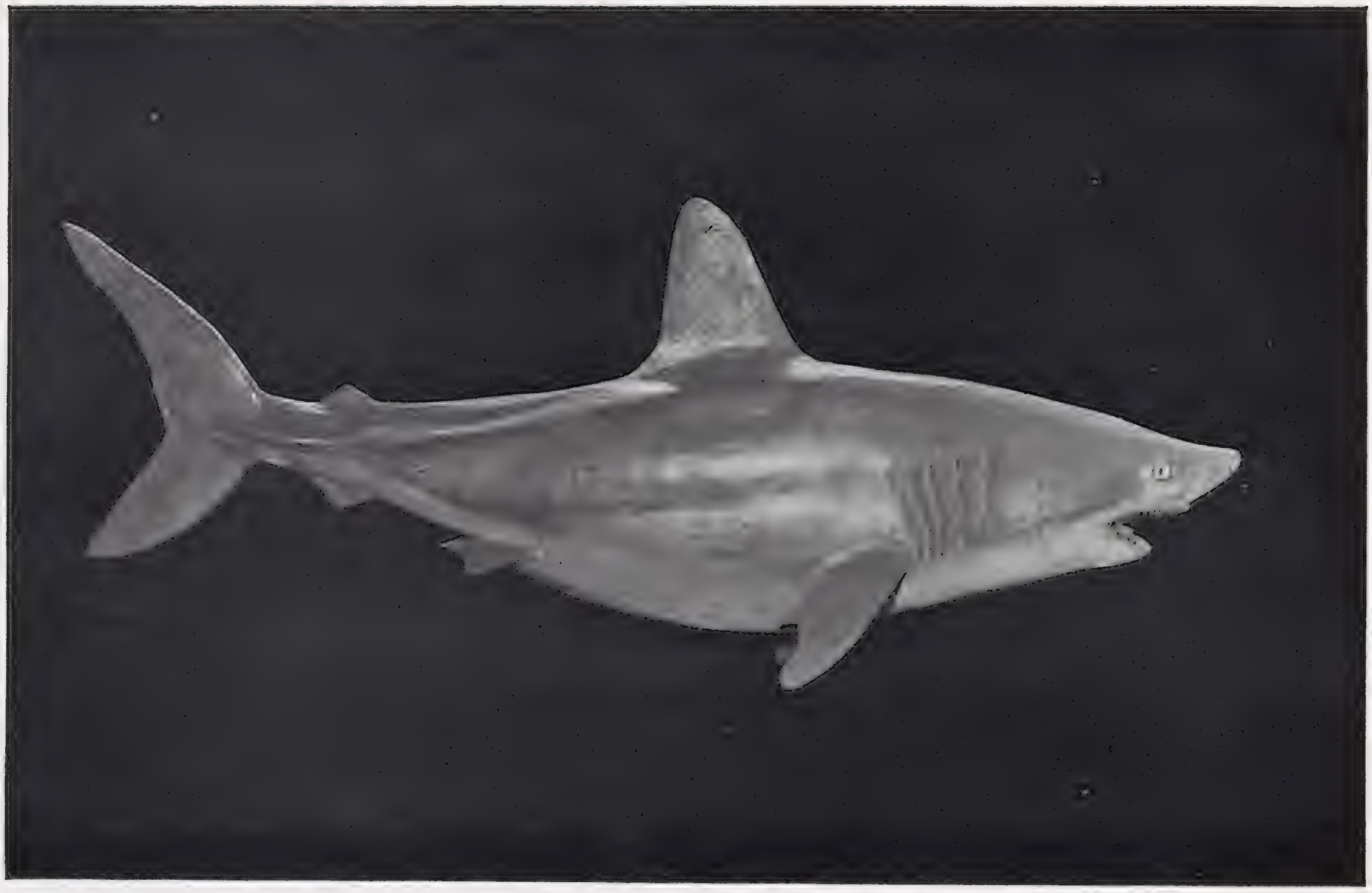
While cruising with the pearl divers of La Paz, I once put on the heavy diving suit and went down on a coral bank, but the promised sharks did not appear. The divers did not fear them, saying that the upward-leaping air bubbles from their helmets kept sharks away. They had however, a wholesome respect for the huge manta rays, always full of curiosity, whose broad wings had been known to hit their air and life lines almost jerking them off their feet.

We refrain from quoting old-time published accounts of killings of human beings by sharks. They are to be found here and there, in the writings of the early missionaries in the South Seas, the early navigators and travellers.

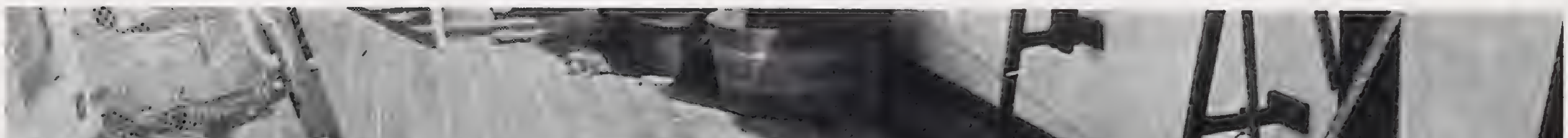
Certain additions to the above mentioned scrap-book during the past three or four years served to reawaken my interest in the shark as a man-killer. Several selected newspaper clippings were sent to naturalists in Hawaii, Australia and Porto Rico with requests for details if obtainable. The director of the aquarium at Honolulu, the economic zoologist of the museum at Sydney and the director of the Bureau of Agriculture at San Juan, all responded to the effect that the killings by sharks all happened practically as reported in local papers:

The letter from Mr. T. C. Roughley, Economic Zoologist of the Technological Museum, Sydney, under date of October 23, 1929, is especially interesting:

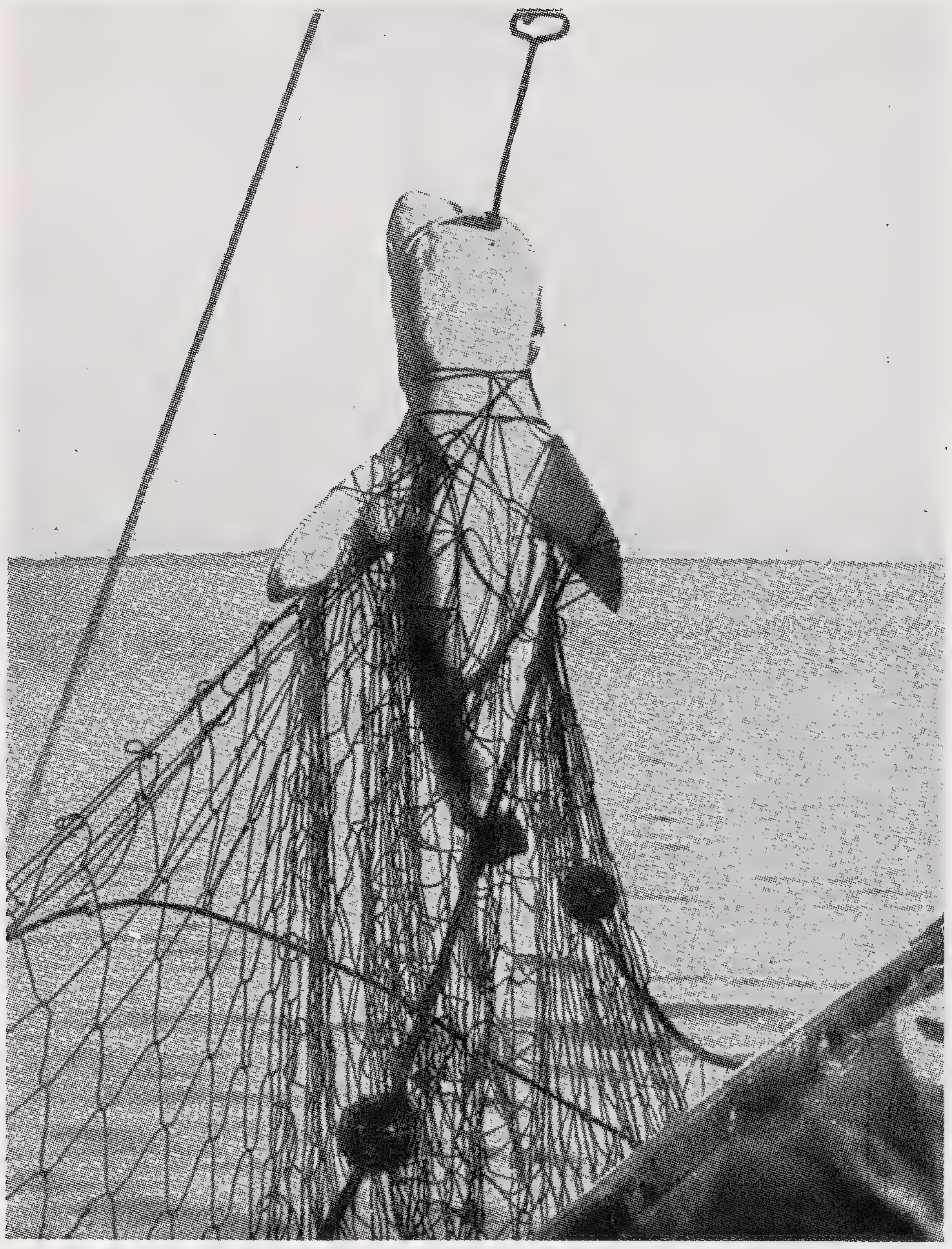
> ". . . . That we have sharks in Australian waters which are a menace to humans goes without saying, for scarcely does a summer pass without one or several fatalities being recorded . . . We usually regard the following species as prone to attack man: Whaler (*Carcharhinus macrurus*), Tiger Shark (*Galeocerdo arcticus*), Hammer-headed Shark (*Sphyrna zygaena*), Grey Nurse (*Carcharius arenarius*), Blue Pointer (*Isurus glaucus*), and the White Shark (*Carcharodon carcharias*).



Great Blue Shark (*Prionace glauca*). A plague to whalemen when "cutting in" whales. From a life-size model in the New York Aquarium.



Sleeper Shark (*Somniosus microcephalus*), coast of Washington. A large northern shark inimical to whales. Reaches a length of twenty feet. A nuisance to northern whalemen. One of many sharks photographed on the U. S. S. *Albatross*.



Whaler Shark (*Carcharhinus macrurus*), effectively enmeshed in a shark net. Photographed by T. C. Roughly. From The Australian Museum Magazine.

"... . Up till about 20 years ago the fatalities were confined to the estuaries, but at about that time surf bathing began to have an extensive vogue, and shortly afterwards an occasional fatality occurred amongst surf bathers, but always when they were swimming outside the first line of breakers. It was thought for many years that bathers were safe so long as they kept in the broken water, but during the last couple of years bathers have on two occasions been attacked right in the surf.

"Persons attacked usually have their flesh torn most frightfully, the amputation of one or more limbs may be rendered necessary, and frequently the patient dies from shock and loss of blood. After the initial attack the shark usually returns quickly and continues the attack until it is frightened away by other bathers rushing to the rescue. There have been many heroic deeds by bathers in their rescues of persons attacked.

"The greatest risk of attack appears to be at dusk; it is then that the greater proportion of the fatalities have occurred.

"... . The number of attacks by sharks upon surf bathers has increased during recent years, but that is probably due solely to the fact that the number of bathers has increased. During the summer months, on week-ends and holidays, some of the ocean beaches in the vicinity of Sydney are so crowded with bathers that it is difficult to move freely in the water. . . ."

Mr. A. H. Chisholm of the Sydney Daily Telegram, at the request of Mr. Roughley, wrote me under date of July 28, 1929, as follows:

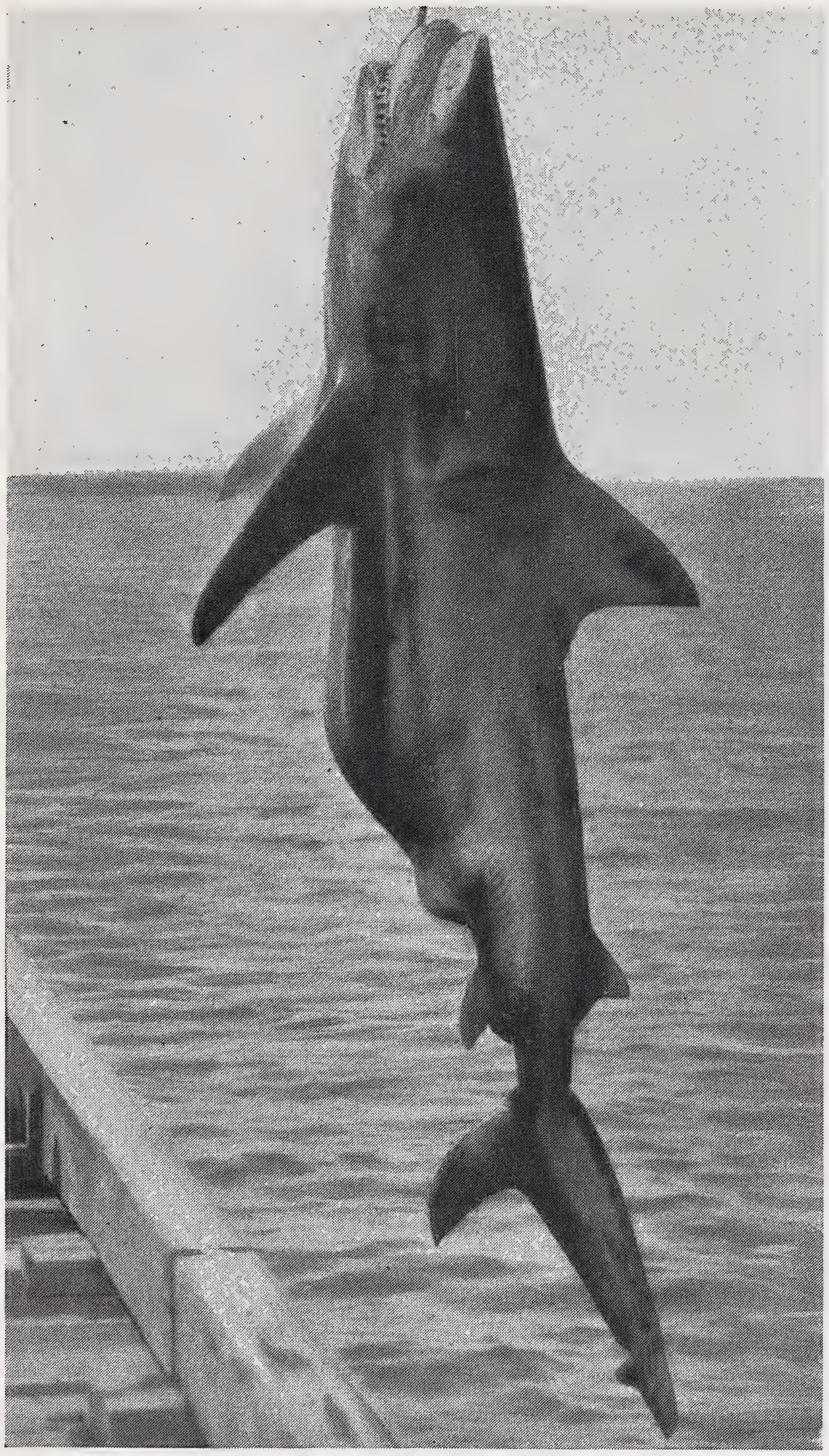
"Pretty well every Sydney beach has its shark tower and warning bell, and, moreover, all kinds of other devices are tried from time to time. The death-roll is not large by comparison (shall we say) with motor mishaps, but the helplessness of the victims, and the shocking manner in which some of them are torn always causes public tumult. In approximately twenty years past some thirteen people have been mauled by sharks on the beaches of Sydney and Newcastle, and the death-roll has been about 40%. . . ."

The following is an extract of a letter received from Mr. Gilbert P. Whitley, Ichthyologist of the Australian Museum at Sydney under date of July 16, 1929:

"... . In Australia, human beings have frequently been attacked by sharks. A special lookout is always kept on the beaches by a man stationed in a shark-tower overlooking the water. When a shark is sighted in the clear water, a bell is rung and the bathers lose no time in leaving the surf. . . .

"... . Some fifteen persons have been badly injured or killed by sharks in New South Wales in the last ten years and it is noteworthy that most of the attacks took place towards dusk and between January and April, when the summer is hottest and people flock to the surfing beaches. Some of the cases recovered after receiving

Skinning a Tiger Shark, Shark-leather Station, Tortola, B. W. I. Photograph from Capt. W. E. Young.



Carcharhinus commersonii. A shark about ten feet long regarded as dangerous in Caribbean and Mediterranean waters. Called Ground Shark in Florida. Photograph from S. A. Williams, Dunedin, Florida.

> frightful injuries whilst the majority of the victims died. . . .
>
> ". . . . The shark menace is a very real one around Sydney in the summer and many efforts at building shark-proof fences across beaches, netting sharks, and catching them by other devices have been made. . . ."

Mr. F. A. Potter, Director of the Aquarium at Honolulu, in addition to reporting on the clippings sent to him cited several other instances of killings and mutilations by sharks. In his comments on the subject he says: "Sharks will at times attack not only men but canoes—when sharks are hungry they grab at anything they see in the water."

Mr. O. W. Barrett, Agricultural Director, Porto Rico, under date of August 28, 1928, reported:

> ". . . . We have had several fatal cases near San Juan during the past five years. . . . One of our worst cases was that of an American school teacher who was swimming too far from the beach, and the whole right hip was taken off with one bite.

In the Journal of Tropical Medicine, October 1, 1930, Dr. J. Burton Cleland, Professor of Anatomy, University of Adelaide, Australia, describes in detail seventeen cases of killings or mutilations by sharks and refers to eleven others described in two previous medical articles published by himself.

Dr. James M. Phalen, U. S. Army, Canal Zone, writes in The Military Surgeon, March, 1929, of a "Fatality from Bite of Shark" in Panama Bay.

Extract from a letter from Mr. John E. Kirby (New York, October 14, 1927) to Captain Dinning and by him sent to me:

> ". . . . Soon after the surrender of the Spanish army at Santiago, Cuba, I was one of a party of thirteen out in a sail boat. The boat capsized and sank. We were compelled to swim to the shore and out of thirteen men the sharks dragged down six. We could see the sharks very plainly. After that we were stopped from bathing by the commanding officer, until a wire mesh was placed to protect us."

During the month of October, 1931, it chanced that three friends in New York spoke of shark accidents:

Mr. Edwin Lefevre told me of attending when a boy, the funeral of a schoolmate in Panama who had been killed by a shark.

Mr. Ralph De Sola told of an attack by a shark which he witnessed in Tampico harbor in June, 1929:

> "Just as the freighter *Casanova* [on which he was a passenger], was dropping her anchor, a member of the crew dove over the side for a swim. He disappeared only a boat's length away. The third mate seized a boat hook and descended into the waiting pilot's launch. The man's head appeared and signs of a struggle were seen as the dorsal fin of a shark appeared near the seaman's head. He was rescued minus a leg, bitten clean off below the right knee, and sent to the hospital."

Mr. H. C. Raven said that while in the Dutch East Indies an officer of a Dutch steamer told him of a fatal shark accident:

> "While anchored off one of the Natuna islands, an engineer was swimming near the ship. A shark appeared and bit off his leg. His body was recovered before it sank."

The Cuban Government on September 5, 1931, cancelled the exclusive shark fishing concession held by a Havana company and declared shark fishing open to the public. This action was taken in the hope of ridding the waters near Havana of man-eaters "which have killed three bathers in the last ten days."

Lack of space does not permit consideration of the abundant note- and scrap-book material remaining at hand on this subject. It extends from the Caribbean Sea to the Indian Ocean and will serve for another equally unpleasant chapter later on.

Fortunately for the commercial fisheries as well as for humanity in general, the recent extension of the shark-leather industry to many parts of the world has served to put a worth-while price on the head and hide of an old criminal still at large, long known to sailors as "Jack Shark."

The steam-powered, whale-killing boat of to-day is usually about 100 feet long and has a harpoon-firing cannon mounted on the bow. Photograph from Bryn, Sandefjord, Norway.

Where the Nineteenth Century Whaler Made His Catch

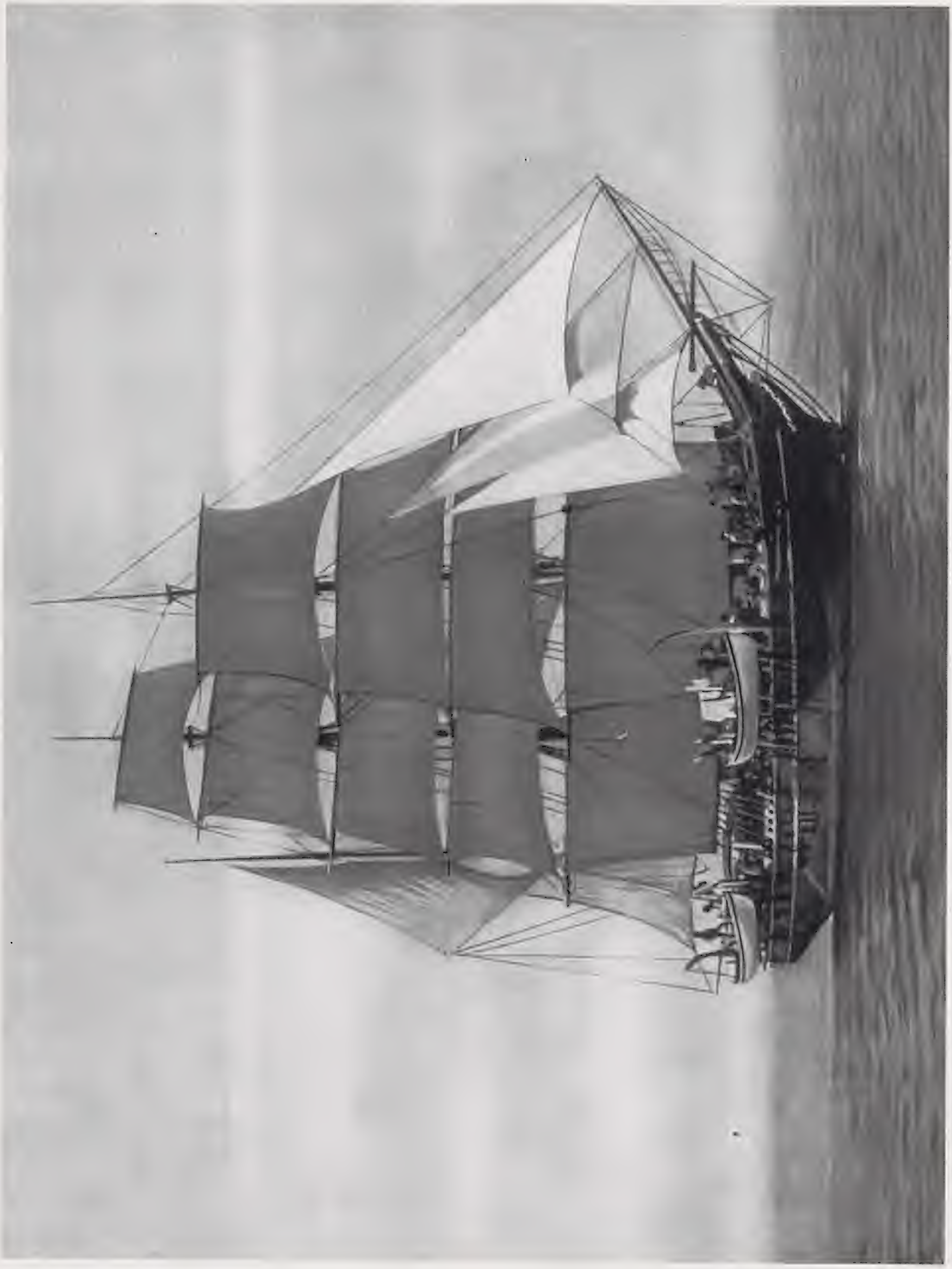
CHARLES HASKINS TOWNSEND

IT has always been recognized that the distribution and seasonal movements of whales in the wide expanse of the seas were not well known.

While examining logbooks of whaling vessels in the New Bedford Public Library, it became apparent to me that they represented a supply of hitherto unused records available for additional information on this subject. The logbooks, hundreds in number, show clearly where the nineteenth century whaler made his catches of sperm, bowhead, right, gray, humpback and occasionally other species. A little experimental plotting on a chart indicated that much could be learned of distribution by extensive work of this sort and by using a separate chart for each species. It was also evident that by using a distinctive color for each month's captures, the movements of whales would be apparent to a considerable degree. The plotting of the positions of whaleships on days when whales were taken, threw light on the locations and dimensions of the "whaling grounds" frequented by the old-time whalers as well as the seasons when they were visited.

Another large collection of nineteenth century logbooks was found in the Whaling Museum of Old Dartmouth Historical Society in New Bedford. Other important collections of whale-ship logs have been located at Nantucket, Salem and other New England ports celebrated in the history of the whaling industry. The compilation of records to be found in these towns will be taken up on behalf of the New York Zoological Society as soon as the work in New Bedford is completed.

The chart presented herewith contains only the first lot of records on sperm whaling. The



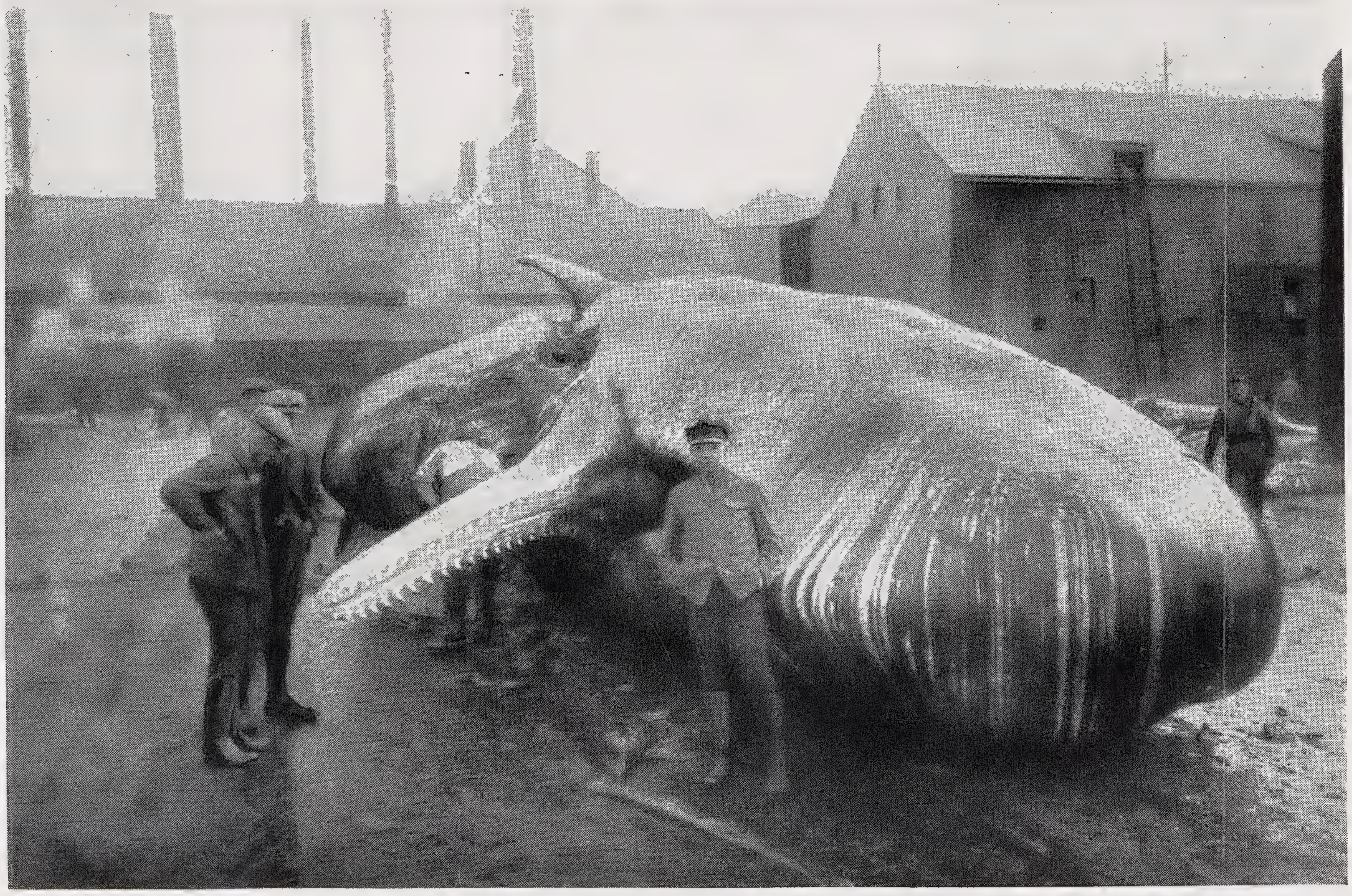
A nineteenth century whaler, the bark *Morning Star* of New Bedford. A sperm whaler of 305 tons built in 1853. Photograph by Tripp, New Bedford.

total number of sperm whales represented by the plottings on it is 11,026. Each month's captures being distinctively colored, they present evidence of considerable movement of whales away from the Equator according to season. A study of this chart shows that the catch of sperm whales by the nineteenth century whaler was made chiefly between the north and south latitudes of forty degrees. The known distribution of this species both northward and southward is somewhat wider. It is in general an inhabitant of tropical and temperate seas, ranging into cold waters only in limited numbers. A few stragglers are now being taken in Antarctic waters. The sperm whaler made voyages lasting from two to four years. He sailed all tropical and temperate seas and operated at all seasons. The "whaling grounds" as shown on the six charts now in preparation are naturally very widely scattered, whales being found in cold, temperate and tropical seas both north and south. Some species are of limited distribution while others migrate extensively according to season, sea temperature, breeding range or food supply.

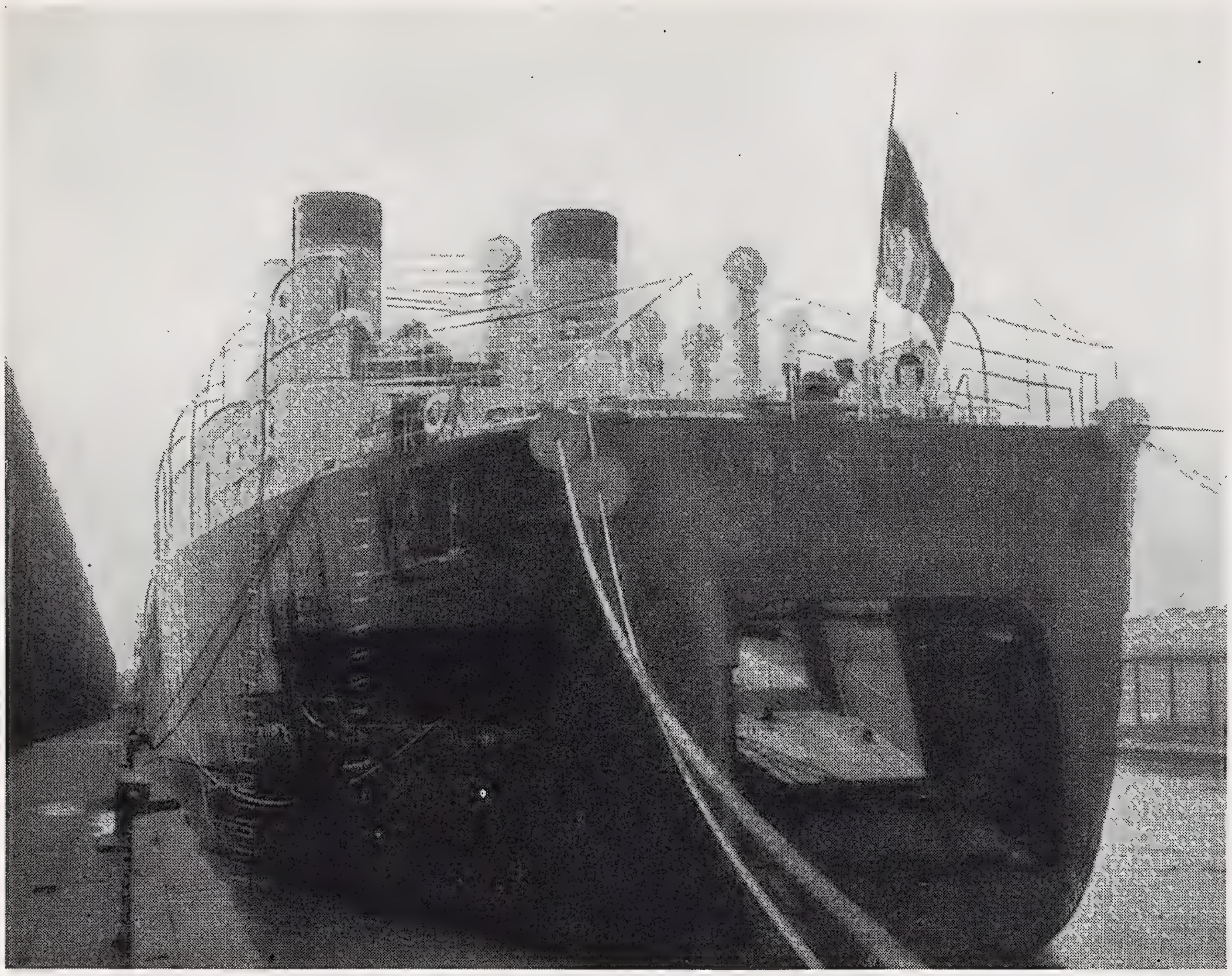
We are here dealing with whaling operations as conducted when sailing vessels were employed and whales were killed with harpoons thrown from open boats. The whales taken were the slower species that could be captured by such methods and that did not sink when killed. The nineteenth century whaler did not take the great blue whale, the finback and other kinds now being captured in great numbers by more effective equipment and his logbooks contain little or nothing about them.

Twentieth century whaling, at present involving the killing of over 30,000 whalebone whales a year, is vastly more destructive. The catch is made by steam-powered hunting boats carrying small cannon and whales are towed to a limited number of stations on shore or to large cruising factory steamers. Forty factory vessels and a smaller number of shore stations are sufficient for the enormous annual catch of today, while the old time sailing fleet numbered hundreds of vessels. In 1846 there were 735 whaling vessels sailing under the flag of the United States. At its best period that great fleet probably captured less than 10,000 whales a year.

The plottings on the sperm whale chart



Sperm whale with mouth open. This is the only large whale with teeth.
Photograph from Bryn, Sandefjord.

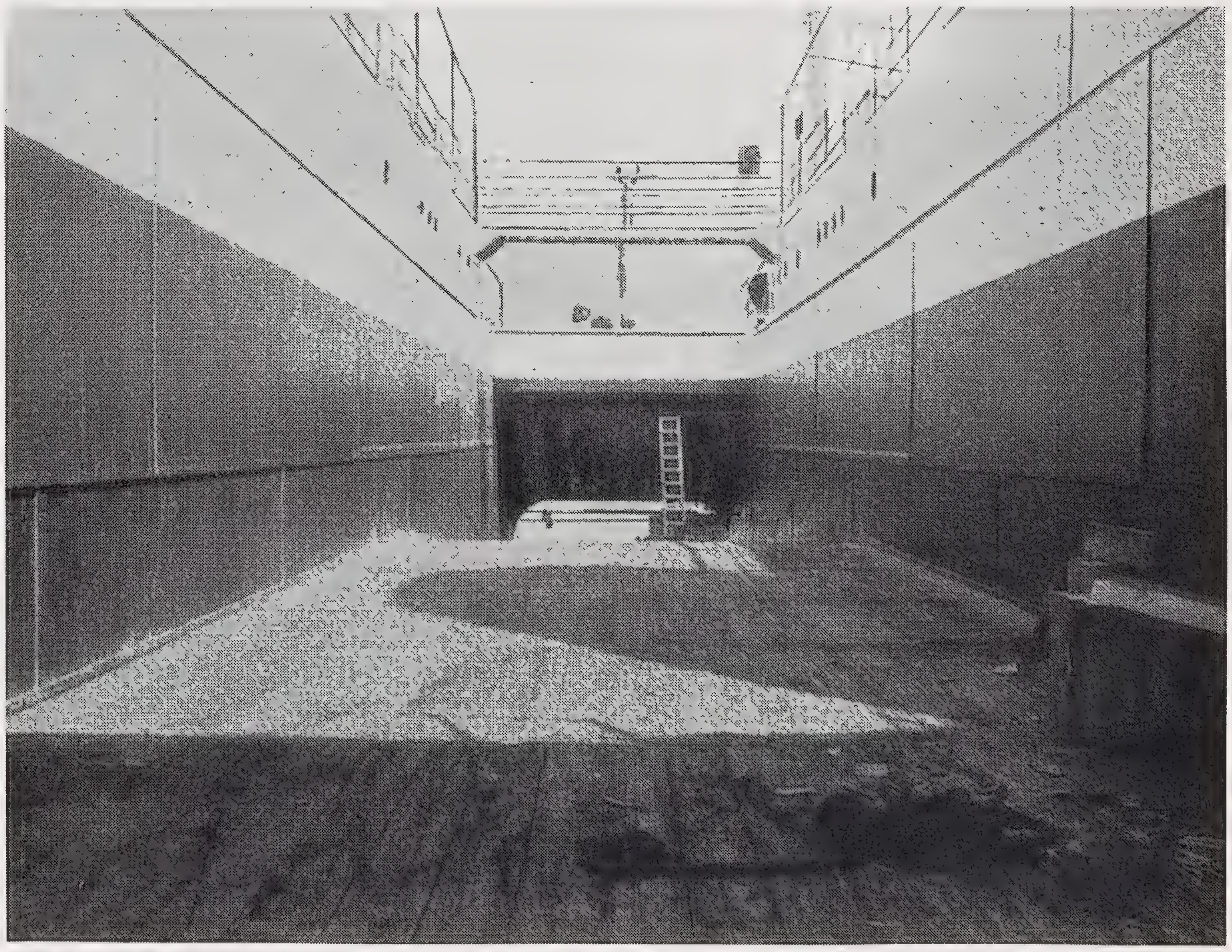


The Antarctic whaler, *Sir James Clark Ross*. Showing slip through which whales are pulled on board. Photograph by C. H. Townsend, 1931.

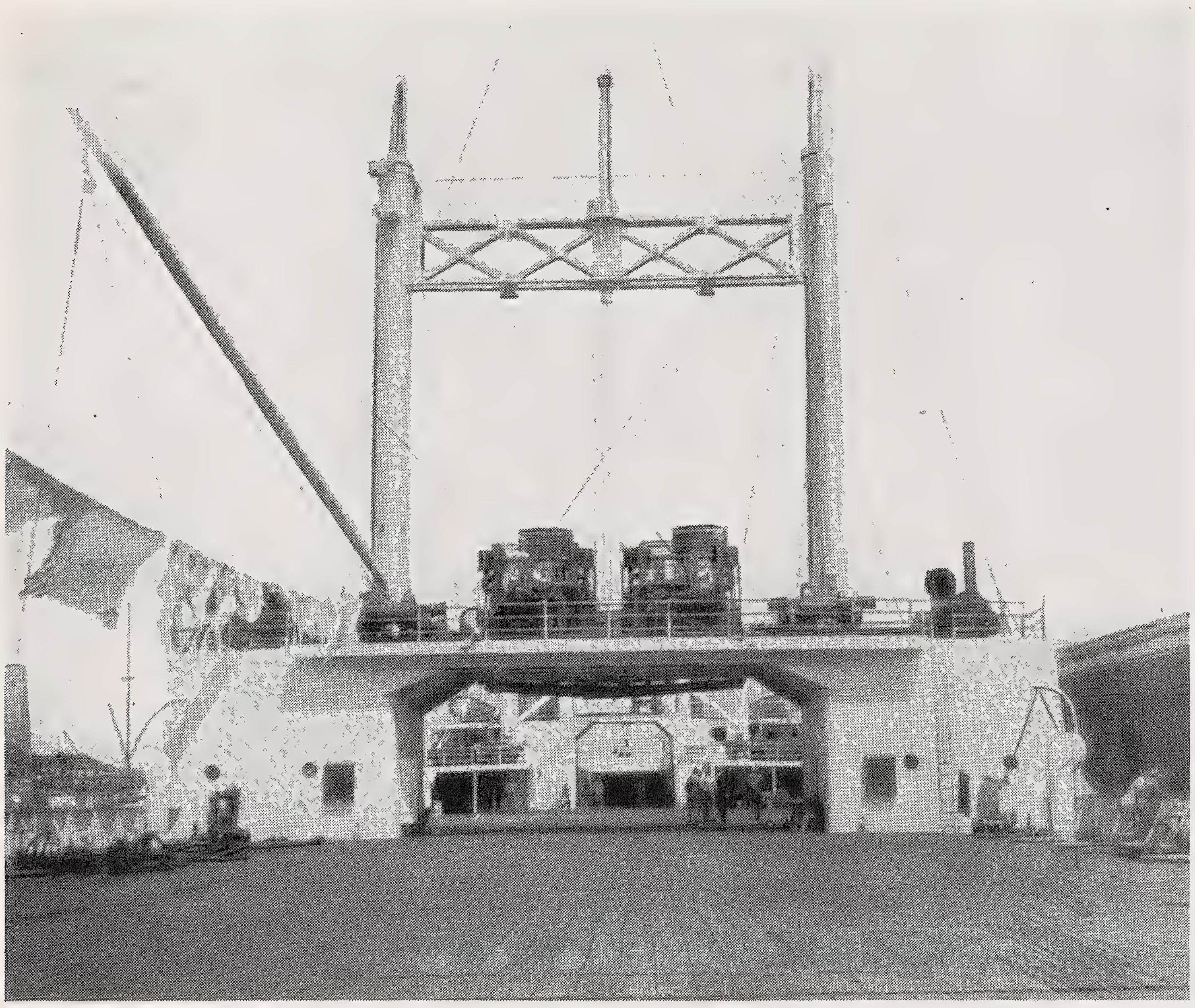
massed along or near the Equator, are confusing. The chart became overloaded with data before we realized that there might be a better method of presentation. As there is a similar supply of records on hand representing perhaps more than 10,000 additional captures of sperm whales, these are being plotted on two charts—one for the April-September season, the other for the rest of the year. These cannot be completed until after further records have been copied from logbooks, especially those coming from Nantucket. The charts already show clearly the seasonal occillation of sperm whales between north and south latitudes.

The plottings on the chart presented in this Bulletin make it of service chiefly as showing positions and extent of whaling grounds. It is not to be expected that the seasonal movements of sperm whales in the broad Pacific will correspond very closely with those of the much narrower Atlantic. The great currents of the two oceans differ in direction and force and there are great climatic differences. The movements of sperm whales in the Indian Ocean are geographically limited at the north. Most of the catch there was made south of the Equator. Such conditions affecting movements of whales as winds, temperature, salinity and food are not considered here. The food of the heavily-toothed sperm whale is altogether different from that of the whalebone whales of paramount commercial importance today.

It will be seen that in the North Atlantic, the plotted areas above latitude twenty-five degrees are with few exceptions, for the April-September period. The massed plottings in the Sargasso region are almost entirely those pertaining to the summer season of the northern hemisphere. Between



Antarctic whaler, *Sir James Clark Ross*. View toward slip through which whales are pulled on board. Photograph by C. H. Townsend.



Antarctic whaler, *Sir James Clark Ross.* View aft along the flensing deck. Photograph by C. H. Townsend.

north latitude twenty-five degrees and the Equator, whales were taken chiefly during the October-March season. Along the east coast of South America, the catches were largely made during the same season or summer time in the southern hemisphere. Along latitude thirty-five degrees south, toward the Cape of Good Hope, whaling data are also for the October-March season. Off Japan and along latitude thirty degrees north, the plottings are those of the April-September season.

In the Pacific and to some extent in the Atlantic equatorial belts, catches for all months of the year are represented. Off the west coast of South America south of the Equator, the plottings pertain mostly to the summer season of the southern hemisphere. There was much whaling off Peru at this season. Off the west coast of South Africa, the extensive whaling during all months of the year may be attributed to the effect of the cool, northward-flowing Benguela Current. The massed areas off the west coast of northern South America, where whaling was also carried on at all seasons, may be similarly explained by the cool northward-flowing Humboldt Current. This current, deflected westward at the Equator is responsible for the uniformly cool sea temperatures about the Galapagos Archipelago where large numbers of sperm whales were taken during more than half a century.

Whaling Grounds.—There is frequent mention in the logs of sperm "whaling grounds," twelve of which were in the North Atlantic: Western Grounds (31°N. 50°W.). This is the great mid-ocean Sargasso region, its center being in the latitude of Bermuda and nearer Bermuda than Madeira. Whaling was carried on here almost entirely during the season from April to September, inclusive.

The Western Islands Ground (37°N.25°-33°W.), was around the Azores where sperm whaling was done mostly in summer. The Charleston Grounds (30°N.70°-77°W.), lay between Hatteras and the Bahamas, mostly to the eastward of the Gulf Stream. The Cornell Ground (6°N.20°W.), was a winter ground between the Cape Verde Islands and the Equator.

The Steen Ground (31°-36°N.21°-24°W.), lay west of Madeira, where sperm whales were taken both in summer and winter. The Two-Forties (40°N.40°W.), lying northwest of the Azores, was visited in summer. On the Twenty-Twenties (20°N.20°W.), north of Cape Verde Islands, whales were taken during the winter months. The Two-Thirty-sizes (36°N.36°W.), southwest of the Azores, was mostly a summer ground. A mid-ocean whaling ground known as the Twelve-Forty (12°N.40°W.), between the West Indies and Cape Verde Islands was visited from February to May inclusive. This area is frequently mentioned in the logs.

The St. Antonio Ground (18°N.26°W.) seems to be about the same as the Twenty-Twenties.

The Southern Ground (36°-38°N.72°-74°W.) had its center in the latitude of Norfolk. It was an extensive Gulf Stream area as indicated by the plottings, frequented almost entirely in summer. The Hatteras Ground, also visited in summer, lay off the Cape along the Gulf Stream.

Another summer whaling ground was called Gulf of Mexico Ground (28°-29°N.89°90°W.). Often mentioned in the logs was the Commodore Morris Ground (50°-52°N.21°-24°W.), a summer whaling field southwest of the British Isles, the most northerly Atlantic sperm whaling ground according to our records, its moderate sea temperature being influenced by the North Atlantic Drift of the Gulf Stream. There were four sperm whaling grounds in the South Atlantic frequently mentioned in the log books: The Brazil Banks, actually off Argentina, (roughly 39°-42°S.57°-60°W.), was also a right whaling ground, first fished about 1774; the Cornell Ground (17°S.8°W.) around St. Helena; the Platte Grounds (34°-37°S.48°-52°W.) off Rio de la Plata, visited by sperm whalers from October to March inclusive, and the Tristan Grounds (33°-39°S.10°-23°W.) being the region around Tristan da Cunha Islands. Woolwich Bay (Walfisch Bay) west coast of Africa, and coast of Patagonia are common logbook names of sperm whaling grounds.

In the North Pacific a sperm whaling region often referred to was the Japan Grounds (29°-32°N.160°-175°E.) extending westward from Midway Island. It was a famous whaling area discovered in 1820. Sperm whaling was also practiced off the coast of Japan but so far we find no logbook name for this ground.

The Off-shore Grounds (5°-10°S.105°-125°W.) lay west of the Galapagos Islands, on and south of the Equator. It was the most famous of the Pacific sperm whaling regions and was visited at all seasons. It was discovered with much acclaim in 1818. The whaling grounds called On The Line lay along the equatorial region westward from the Off Shore Grounds. Sperm whales were taken there at all seasons.

French Rock Grounds (32°S.180) fished during most of the year, lay around the Kermadec Islands north of New Zealand. Middle Ground was between New Zealand and Australia.

Whalemen often referred to other Pacific sperm whaling areas, the positions of which are obvious: Panama Bay, Galapagos, Coast of Chili, Callao and Coast of New Holland (or later Australia) generally in reference to the west and south coasts. Among the islands between Australia and the Philippines there was sperm whaling at all seasons, one area being the Sooloo Ground in the Mindoro Sea. There was a distinct seasonal movement of whales between the Sulu Sea and the Celebes Sea. Sperm whaling grounds in the Indian Ocean were known as Coast of Arabia, Mahe Banks, Seychelles, Delagoa Bay, Zanzibar and Mozambique. Whaling in the Arabian Sea (Lat. 15°N.) was done chiefly in December and January.

In listing the sperm whaling grounds, frequented by the old-time whalers, we have taken only the names used in the logbooks. Other grounds are referred to but not in connection with sperm whaling.

It should be explained that on a few whaling grounds where the plottings are very dense, the draughtsman extended the areas slightly for lack of space. These are off the west coast of South Africa and off the east coast of South America; around the Galapagos Islands; off Northern New Zealand and off the north coast of Japan.

In other charts now in preparation, this difficulty is avoided by omitting some of the data, rather than extend the ground beyond actual whaling limits.

The sperm whale, formerly abundant, still figures in the catch of the twentieth century whaler. It is taken, but to a very limited extent, mostly at shore stations on the coasts of Japan, Norway and South Africa, stragglers being found as far south as South Georgia and the summer border of the Antarctic ice. The total number of sperm whales taken during the season of 1929-30 was 1,352, the world catch of all species for that period being 38,563—the greatest number of whales ever taken in one season.

The additional charts in preparation for the New York Zoological Society will show positions where many thousands of whales, of five species, were taken during the nineteenth century.

The Whaling Season of 1929-1930

The Norwegian Whaling Gazette in the September number of 1931 announces the world catch during the season of 1929-1930 to have amounted to the surprising number of 38,563 whales. Of this record number, 19,080 were blue whales, 14,350 finback, 1923 humpback, 922 sei, 1,352 sperm and 936 of other species. The bulk of the catch, 30,654 whales, was made in Antarctic waters and chiefly by Norwegians. The remainder, 7,909, were taken in tropical and northern seas, that of Japan being largest with 1,714 whales. Thirty of these were the rather scarce gray whales, confined to the North Pacific and 753 were sperm whales.

Operating off the Santa Barbara Islands along our own coast and off Lower California, the whaler *Lansing,* with which the writer cruised in 1929, took 300 whales. Shore stations in Alaska and British Columbia captured 675 whales.

On April 20 the writer boarded the Norwegian Antarctic whaler *Sir James Clark Ross* at Staten Island where the vessel's catch, 55,000 barrels, was sold to one firm for soap making, at an estimated value of over $1,500,000. The *Ross* had seven steam whale-killing boats, a crew of 245 men and had taken during the season 1,445 whales. This vessel was followed to Staten Island ten days later by the Antarctic whaler, *C. A. Larsen,* with a catch of whales nearly as large. The total world yield of whale oil for the season of 1929-30, exceeded 3,427,000 barrels. There was great overproduction and most of the oil went to storage, with the result that whaling in general is suspended for the present year. The whales need a respite, in fact a longer one than they are likely to get.

The Antarctic field, in the whaling industry of the past few years, has been exploited with remarkable intensity.

◆

The Supply of Fresh-water Fishes

During recent years the Aquarium has found it increasingly difficult to maintain a satisfactory collection of Eastern fresh-water fishes. The local sources of supply, fairly productive twenty-five years ago, no longer yield fishes of the larger sizes. The exhibits of basses, perches, pickerels, catfishes, sunfishes, et cetera, representing numerous species of these families, have long consisted of rather small specimens.

Among the causes contributing to the diminution of the supply are a great increase in the number of anglers, as a result of extensive road building, and the ever rising numbers of automobiles cruising through the rural sections of the whole country. Angling waters have become more and more accessible to campers. Waters once pure now suffer from manufacturing wastes, sewage and oil washed from highways. The fish supply of the markets is now derived chiefly from the sea. There is little fresh-water market stock available except what comes from the Great Lakes, the lakes of Canada and the Mississippi River. The Great Lakes have suffered from long-continued and exhaustive commercial fishing.

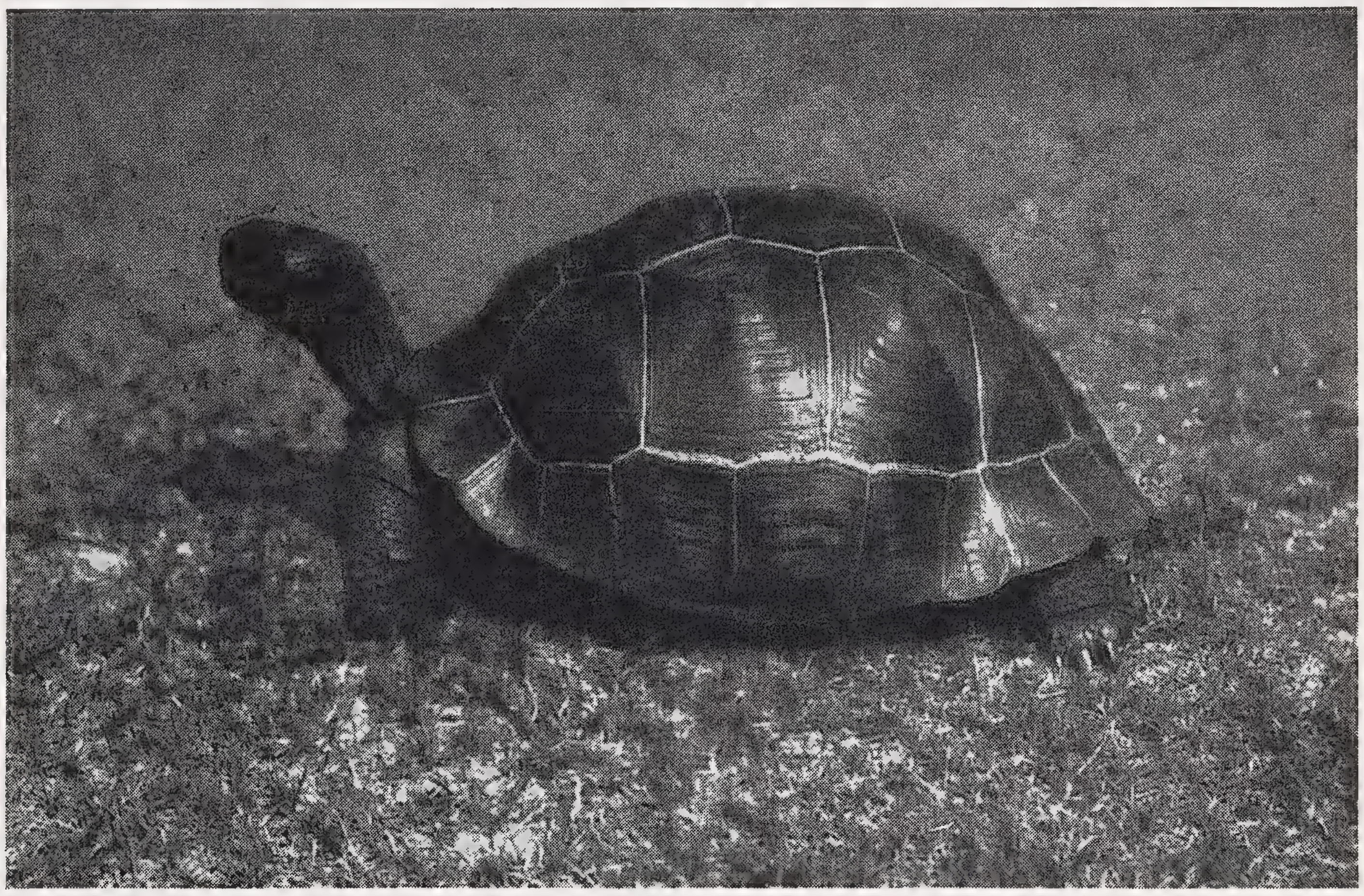
In May of the present year the Aquarium secured a truck so that its collector could go farther afield. Permits were obtained for the drawing of seines in distant reservoirs where larger fishes were secured "strictly for exhibition in the Aquarium." This effected considerable improvement in our collection but the results were not all that could be desired. As many years had passed since the Aquarium received fishes from the Mississippi, it seemed advisable to vary the collection with additional species. Accordingly, two of our men were sent to the Government Fisheries Station, at Fairport, Iowa, where they secured about two thousand fishes by seining in the great river. These were held in the Government ponds at Fairport until the work of collecting was completed. By special arrangement with the Nuchem-Messing Live Fish Corporation of New York, one of their tank cars, used in the transportation of live fishes, called at Fairport on its return trip and brought back the Aquarium collection.

In addition to larger specimens of widely distributed fishes, not readily available in the East, there were numerous species belonging to the Mississippi and its tributaries. Among the latter are shove-nose sturgeon, fresh-water drum, buffalo fish, white bass, yellow bass, quill-back sucker, moon-eye, gizzard shad, channel catfish, crappie and various sunfishes. The arrival of these and others equally interesting, has provided a good exhibit of fresh-water fishes.

Growth of Galapagos Tortoises

CHARLES HASKINS TOWNSEND

IN a recent issue of Zoologica,[1] the writer published certain records showing the growth of Galapagos tortoises in captivity. Brought to the United States by the writer early in 1928,[2] by authority of the Zoological Society. Located at several places in the South where climatic conditions were believed to be favorable, most of them have increased rapidly in size.



Galapagos Tortoise (*Testudo vicina*). Weight, October 1, 1928, forty-eight pounds. Its growth was slow until January, 1930, when as the result of heavier feeding, the white lines indicative of rapid growth began to develop. Its weight on August 1, 1931, was eighty-seven pounds. It is about twelve years old.

As these animals are known to attain weights exceeding 500 pounds, they were popularly supposed to be of slow growth. Tortoises of great size were believed to have lived a century or more. The records of growth of the Zoological Society's colonies were, when published, surprising to most naturalists. The rate of increase in size has continued to be rapid since their individual weights were recorded in 1930. The following table shows the total weight attained by each colony between 1928 and 1931:

Place	Number of tortoises	Total lbs. 1928	Total lbs. 1931	Increase %
Brighton, Fla.	5	35	254	626
Opa-Locka, Fla.....	5	42	248	490
Biscayne Is., Fla....	18	334	714	114
Lignum Vitae, Fla..	8	248	635	157
New Orleans, La...	7	100	365	265
Houston, Texas	14	192	984	413
San Antonio, Texas.	8	111	455	310
Superior, Ariz.[3]	3	71	126	77
San Diego, Calif....	19	479	1411	195
Bermuda	10	66	299	355
Honolulu, T. H.....	6	159	434	173
Sydney, Aus.	6	20	35	75

The uneven rates of growth among the different colonies of tortoises as shown in the above record, are attributable to location and method of treatment. The tortoises in Arizona lived almost entirely on prickly pears, abundant in the cactus grove where they were confined. There were also some early losses in Arizona from cold weather. Those on Lignum Vitae Island subsisted entirely on grasses. All the others lived on grassy ranges in public or private zoological gardens where they also received a variety of vegetables. Very generous feeding at some places served to stimulate growth.

There have been as yet no signs of breeding. Only a few of the tortoises have reached weights exceeding 100 pounds. The breeding age is unknown.

Having among these tortoises three individuals held in captivity at Guayaquil, Ecuador, from infancy, we find that the annual rings of growth on their plates correspond with their known age.

A few young tortoises are still retained at the New York Zoological Park where their growth has been much slower than among those located in the South.

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[1] Zoologica Vo. IX, No. 13. N. Y. Zool. Soc. 1931.
[2] Zoological Society Bull. Sept.-Oct. 1928.

[3] Tortoises now at Opa-Locka, Florida.

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SPERM WHALING GROUNDS OF THE NINETEENTH CENTURY

Based on Logbook Records Dating from 1821 to 1899

Each colored plotting represents the position of a whale-ship on a day when one or more sperm whales were taken. Each month's whaling is colored distinctively (See at left, key to colors). Positions in full represent an aggregate catch of 11,026 sperm whales.

Prepared under the direction of Charles Haskins Townsend. Records compiled by A. C. Watson. Draughtsman, R. W. Richmond.

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New York Zoological Society

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Forms: Information concerning membership can be obtained at the Aquarium or the Zoological Park, where application forms will be furnished on request. Signed applications for membership may be given to the Director of the Zoological Park, the Director of the Aquarium or mailed directly to the Secretary, William White Niles, 101 Park Avenue, New York City, for action by the Executive Committee of the Society.

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